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ANIMAL MUSIC, ITS NATURE AND ORIGIN.

BY XENOS CLARK, B.S.

THE songs of birds and the few other animals that sing, have almost exclusively been treated of in the world of sentiment, where poet-naturalists and nature-poets have culled a wealth of fancies that will endure as long as there is human emotion, but which count for little in the field of exact knowledge. They are choice reading; a kind of pleasure gardens. The purpose here is simply to bring together such songs as have been written in musical notation, and from this compilation to make whatever inductions may seem of scientific value to ornithologists, physiologists, psychologists and theoretical musicians, whose studies touch this subject.

The young bird acquires his song by traditional inheritance; that is, each brood, endowed by physiological inheritance with a certain aptitude, learns, after long practice, by constantly hearing the song of its elders, the melody peculiar to that species, which is in turn similarly transmitted to the succeeding generation. In conclusive proof of this is the fact, that a young nestling reared by foster-parents of some other species will learn their song. Hon. Daines Barrington (1),[1] an early and discriminating observer, says, "I have educated nestling linnets under the three best singing larks, the skylark, woodlark and titlark, every one of which, instead of the linnet's song, adhered entirely to that of their respective instructors." This process seems very decisive, for a titlark-linnet (a linnet educated by a titlark), well fixed in song, which he kept for three months with common linnets in full song, borrowed no passages, but adhered to the titlark melody. It

[1] The references are made by Roman numerals to the list at the end of the article.

is evident, therefore, that birds acquire their songs as infants acquire a language, by instruction rather than by instinct; and that those of the same species sing alike for the same reason that children of one nationality speak alike, viz: that their instructors have a common tongue.

The next question is, how birds came originally by the notes which are peculiar to each species. Daines Barrington answers this also, saying substantially that scarcely any two birds of the same species sing exactly alike; there are, so to speak, "provincial dialects" in different districts, as well as individual mannerisms and defects. All these minor differences, continually renewed, will be imitated by the young birds, and passing from them to succeeding generations, will be perpetuated and grow to wider divergencies. The loss of a parent at the critical period, also, will compel the young bird to invent or copy from other birds, perhaps of different species. Had this explanation been thought out a hundred years later, in 1873, it would have been added that of all these variations sexual selection would perpetuate the most agreeable, so that, as Darwin says (II, p. 378), "It is not difficult to imagine the steps by which the notes of a bird, primarily used as a mere call, or for some other purpose, might have been improved into a melodious love song."

The ultimate origin of melody is a more difficult problem. Darwin writes elsewhere (II, p. 569), "But if it be further asked why musical tones in a certain order and rhythm give man and other animals pleasure, we can no more give the reason than for the pleasantness of certain tastes and smells." I will attempt here to briefly answer this question, reserving at present the fuller statement of a theory, which, very strangely, has never before been hit upon, though Darwin in the paragraph preceding that just quoted, and Helmholtz (III, p. 553) have almost come upon it, and then passed by.

A musical sound is compound in its structure, being really a group of simple tones heard simultaneously; in fact, a chord. This group is composed of a ground tone or fundamental, which predominates, and of a number of overtones, that decrease in intensity as they rise in pitch through a series of harmonic intervals. Thus between the ground-tone and over-tone No. 1 is the interval of an octave; between Nos. 1 and 2, of a fifth; between Nos. 2 and 3, of a fourth; between Nos. 3 and 4, of a major third (see songs No. 1). These intervals, the octave, fifth, fourth

and third, which thus occur in every musical sound we hear, and which existed as physical peculiarities of vibrating bodies long before any living being came upon the earth, are also at the basis of human and, I hope to show, extra-human melody. It is a very suggestive coincidence, too thorough-going to have occurred by chance. The thought at once arises that the peculiar, compound, harmonic structure of musical sounds (more accurately, of the vibrations which produce them) has in some way impressed itself upon the auditory mechanism; so that melody, gradually growing under the guidance of the ear thus modified, has been moulded into a musical form similar to that possessed by the group of harmonically-related tones which we have seen to compose the sounds indicated.

This seems very probable. For since each terminal nerve of the thousands in the cochlea responds to a given simple tone, the group of such tones forming a musical sound will excite a corresponding group of nerves, which will of course be related amongst themselves as are the exciting tones amongst themselves; that is, they will be serially octaves, fifths, fourths and thirds apart. Every nerve will, therefore, have always been stimulated in company with certain others, at harmonic intervals from it; and it is inevitable that the incessant and long continued repetition of this coöperate activity should have resulted in some anatomical or functional bond; a pathway, as it were, leading from each member of the group to every other. *The progress of any melody will be easiest along this harmonic pathway, worn by the physical structure of sound.*

For this reason it seems to me, "musical tones in a certain order give man and other animals pleasure."[1] Take the case of some primitive bird of the type from which the various Insessores have diverged (singing birds belong chiefly to this Order). For innumerable years the harmonic structure of sound vibrations had been impressing itself upon the auditory mechanism of his ancestors, segregating the terminal nerves, or whatever the auditory units might be, into groups, and habituating the members of each group to concerted activity. He, in turn inheriting that

[1] The word *pleasure* has been a stumbling block. Were the concretes of which it is the abstract always expressed, thus—"I feel an easy performance of some function; or a general nervous stimulation and exaltation; or an impulse to continue this sensation or action"—were this done, many seeming difficulties of physio-psychology would vanish.

modified mechanism, began to sing, at first a single note. When this grew wearisome and for remedy the pitch was altered, true song arose. But the change of pitch could hardly have been at haphazard; the first note excited a nerve belonging to a certain coherent group, and it was a necessary alternative that the next note should excite some other nerve, either within or without that group. If within, the combination had occurred millions of times; if without, perhaps not once. I cannot doubt that the change was within the group; was harmonic; indeed the overtones of the first note had already slightly stimulated the related nerves, so that their faint tremor extended, as it were, an invitation to touch them more firmly. The invitation was followed, and then other similar ones, and finally the song grew harmonic, because it followed the easy, preëstablished pathway, rising and falling octaves, fifths, fourths and thirds from one to another of the many-grouped nerves. He sang to please himself or his mate, and the most pleasing combination of notes was that most easily heard; the combination producing least friction and securing the most economical action of the sound-receiving apparatus.

In this brief exposition all details are neglected, and even inexactness admitted where rigorous truth of statement would consume too much space. The more technical treatment of the theory, if it can be called that, belongs to physiological acoustics, in which province many facts tend to its support. The further evidence that can be appropriately presented here, consists of certain statistical proofs gathered from the bird songs which occupy the last pages of this article, and it seems very conclusive.

There are four hundred and six intervals in the thirty-eight bird songs. Of these, all below the major third may be considered as a "filling in"—material for runs, trills, etc.; they number one hundred and eighty-four.

The major third and the intervals above it are the true progressive steps followed by the bird's ear in the long leaps of his song; there are of these two hundred and twenty-two. The following table will show the details:

Interval	Maj. 3d.	4th.	Dim. 5th	5th.	Mi. 6th.	6th	Dim. 7th	7th	8th.
No. of tones . . .	2	2½	3	3½	4	4½	5	5½	6
Absolute No. . .	58	55	5	60	12	8	4	. . .	20
Proportional No.	26 per ct	25 per ct	2 per ct.	27 per ct	6 per ct	4 per ct.	1 per ct.	. . .	9 per ct.

These results are as pregnant as they are simple. The perfect fifths, fourths, thirds and octaves have a marked predominance, their proportion of the whole number being respectively twenty-seven per cent., twenty-five per cent., twenty-six per cent. and nine per cent., or taken all four together, eighty-seven per cent. as against thirteen per cent. of the remaining five intervals. Nearly all the songs illustrate this pronounced harmonic character; that of the song sparrow (Nos. 18–22), for example, in which the best intervals lie between the trills, is very good. Indeed, the very fact that various keys are selected in which to write bird songs is proof that they rest on the same basis as human music. And the immense preponderance of harmonic intervals seems sufficient answer to whatever may be said about the difficulties and possible inaccuracies attendant on the writing of these songs.

There are some curious observations on the singing of birds in concert which seem to show that they have an "ear for music." Daines Barrington (I) says that, as tested by trained ears, a dozen singing birds of different kinds in the same room made no disagreeable dissonance. And Mr. Augustus Fowler writes me that in a meadow where many red-winged black-birds are congregated, one may "hear their familiar notes pitched to the same key; not a discordant note is uttered because the intervals are thirds, fifths, etc." In a concert of male goldfinches, when they sing for an hour together, "although one may pitch his tune and commence singing, the others following, begin their tunes on the same pitch, and to an unpracticed ear, or to a casual observer, their notes seem discordant, when they are in perfect unison."

What few songs of other animals than birds can be gathered, point even more strongly in the same direction. Darwin (II, p. 567), speaking of the *Hylobates agilis*, an ape allied to man, says, "This gibbon has an extremely loud but musical voice. Mr. Waterhouse states (XVI), 'It appeared to me that in ascending and descending the scale, the intervals were always exactly half-tones, and I am sure that the highest note was the exact octave to the lowest. The quality of the notes is very musical; and I do not doubt that a good violinist would be able to give a correct idea of the gibbon's composition, excepting as regards its loudness.' Mr. Waterhouse then gives the notes. Prof. Owen, who is a musician, confirms the foregoing statement. This gibbon is not the only species in the genus which sings, for my son, Francis Darwin, attentively listened in the zoölogical gardens to *H. leu-*

ciscus whilst singing a cadence of three notes, in true musical intervals and with a clear musical tone."

The Rev. S. Lockwood writes in the AMERICAN NATURALIST (VI) of a most interesting singing mouse, *Hesperomys cognatus*, and fortunately gives the music, written by his son (Song No. 39). He says, "Although she had no ear for time, yet she would keep to the key of B (two flats) and strictly in a major key. Her soft clear voice falls an octave with all the precision possible, then at the wind up it rises again into a very quick trill on C sharp and D. When singing whilst turning in her wheel, and suddenly thrown on her back by its stoppage, as if in surprise, she would roll off four or five notes in a higher octave, and in a greatly increased loudness of voice.'

In answer to some inquiries, Mr. Lockwood kindly writes me as follows: "Octaves, fifths and thirds were usually selected for the long intervals of *Hesperomys*' song. I have had and still have singing guinea pigs, *Cavia cobaia*. What is said of my *Hesperomys* is in the main true of the *Cavia*. There are other rodents that sing, *Mus musculus*, or house mouse; the rat, *Mus rattus*; the white-footed mouse, *Hesperomys leucopus*; the woodchuck, *Arctomys monax*, and the squirrels." Recent numbers of *Nature* (VII) and the *Popular Science Monthly* (VIII) contain brief accounts of singing mice. That in the former confirms some curious phenomena observed by Mr. Lockwood—the singing of an air with an accompaniment, and the influence of fright as well as joy in starting the song.

It is doubtful whether true music is produced by any invertebrates. There seems to be no provision in the ear for the exact discrimination of pitch, and the sounds are instrumental rather than vocal, being generally produced by stridulation. Some references, however, are given with the others to what has been written on this subject (XXII to XXVI, see also II, pp. 274, 289, 301).

For assistance in my work of collecting and studying animal songs I am much indebted, especially to Mr. Wilson Flagg, Prof. E. R. Sill, Dr. Elliott Coues, Rev. S. Lockwood, Mr. H. A. Purdie, Mr. Robert Ridgway, Miss Alice Bacon, Mr. H. D. Minot and Dr. P. L. Hatch. It was necessary that the work should be largely one of compilation, for the material had never been brought together before. Thus the attempt has much of a pioneer character, and my chief hope is to direct attention to this important field of study, where acute observation is very much

needed; for the comparative sciences hold the keys to all questions of origin, and their method is simply the intelligent noting and collating of the facts of Nature. Allegiance to this method in the field of animal music has even at this early stage resulted in two encouraging starting points for future work—a statistical demonstration of the harmonic character of animal, especially bird, song; and a theory for the origin of melody, whether human or extra-human, which besides the usual basis of physiological acoustics, employs the law of modified, inherited, selected and adapted structure, *i. e.*, the law of evolution.

BIBLIOGRAPHY.

I. The Hon. Daines Barrington, "Philosoph. Transact," 1773, p. 249.
II. Darwin, "The Descent of Man," Appleton & Co., 1875, 2d ed.
III. Helmholtz, "The Sensations of Tone as a Physiological Basis for the Theory of Music," trans. by A. J. Ellis. London, 1875.
IV. James Sully, "Sensation and Intuition." London, 1874, 7th essay.
V. Grant Allen, M.A., "Physiological Æsthetics." London, 1877. Hearing.
VI. Rev. S. Lockwood, "A Singing Hesperomys," AMERICAN NATURALIST, Vol. v, 1871, p. 761.
VII. "Singing Mice, *Nature*, Nov. 8, 1877, p. 29.
VIII. "Singing Mice," by Henry Lee, *Pop. Science Monthly*, Vol. XIV, 1878, p. 102.
IX. White's "Natural History of Selborne."
X. Kircher, "Musurgia"—Notes of nightingale, quail and cuckoo.
XI. Wilson Flagg, "Birds and Seasons of New England," Boston, 1875. This contains all correct songs of those printed in *Atlantic Monthly*, 1858.
XII. "Music of Nature," by Gardiner. London, 1832.
XIII. "Book of Nature," by Good, p. 189. Hartford, 1853.
XIV. John Blackwall, Mem. Lit. and Phil. Soc. of Manchester. 2d Series, Vol. IV, 1824, p. 289.
XV. "Ornithological Dictionary," 1833, p. 475.
XVI. Given in W. C. L. Martin's "General Introduc. to Nat. Hist. of Mamm. Animals," 1841, p. 432; Owen, "Anat. of Vertebrates," Vol. III, p. 600.
XVII. J. E. Harting, "The Birds of Middlesex." London, 1866. Numerous songs.
XVIII. Kennedy. *N. Abhandl. baier. Akad.* (*Phil. Abhandl.*), 1797, p. 169.
XIX. Savart (*Froriep's Notizen u.s.w.*), 1826, pp. 1 and 20.
XX. Brehm and Hausmann, *Naumannia*. 1855, pp. 54, 96, 181.
XXI. *Journ. für Orn.*, 1855, p. 348, 1856, p. 250.
XXII. "The Songs of the Grasshoppers," by S. H. Scudder, AMERICAN NATURALIST, Vol. II, 1868, p. 113.
XXIII. "Stridulating Crustaceans," *Nature*, May, 1878, pp. 53 and 95.
XXIV. Insect Music, Landois' *Das Ausland*, XLIII (1870), pp. 429 and 430.
XXV. Stridulation of Scorpions. See "Annual Rec. of Science" (Baird), 1877, p. 282.
XXVI. Stridulation of Butterflies, See "Annual Rec. of Science" (Baird), 1877, p. 309.
XXVII. *Language et chant des oiseaux*, par M. F. Lescuyer. (Paris, J. B. Baillière et Fils.)
XXVIII. *Il Canto Degli Uccelli*, note di fisiologia e biologia zoologica in rapporte alla scelta sessuale e alla lotta per l'esistenza raccolte du *Luigi Paolucci*, Professori di Storia Naturale nel R. Instituto Tecnico di Ancona. (Milano, 1878, pp. 130.) This is an elaborate and philosophical memoir treating of animal song in many separate aspects. The notes of insects, batrachians, reptiles and birds are given in musical notation, and elaborately discussed. No less than twenty bird songs are thus written on the gamut, and the peculiar melodic quality of sixty-eight more tabulated. We hope to review this important work in a succeeding number of the NATURALIST.

There are so many possible arrangements for these songs that it seems best to group them according to source, all from one writer in succession. No addition is made in any case to the original text; the names, vulgar or scientific, or both, are given without change. No. 1 is the fundamental C with its overtones (III, p. 33).

Gardiner's "Music of Nature" (Nos. 2–4).

2. **Lark,** England.
3. **Nightingale.**
4. **Robin.**

"The Birds of Middlesex" by J. E. Harting (Nos. 5–15).

5. **Blackcap,** *Sylvia atricapilla.*
6. **Willow Warbler,** *Sylvia trochilus.*
7. **Yellow-Hammer,** *Emberiza citrinella.*
8. **Ring Plover.**
9. **Peewill.**
10. **Oystercatcher.**
11. **Little Ring Plover.**
12. **Whimbrel.**
13. **Curlew.**
14. **Dunlin.**
15. **Swan.**

"Birds and Seasons of New England," by Wilson Flagg (Nos. 16–31).

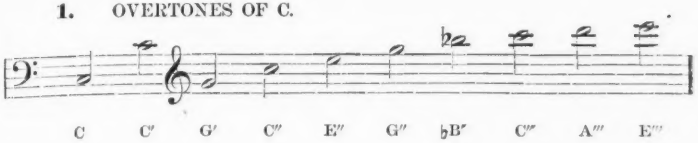
16[a]. **Song Sparrow,** Theme.
17[b]. " " Brisk. (The notes marked guttural seem to be performed by a rapid trilling of these notes with their octaves).
18[c]. **Song Sparrow,** Joyful.
19[d]. " " Plaintive.
20[e]. " " Fervent.
21[f]. " " Subdued and querulous.
22[g]. " " Brilliant.
23. **Peabody Bird,** *Fringilla albicollis.* (This is a corrected song, sent me by Mr. Flagg.)
24. **Vireo—"The Brigadier."**
25. **Wood Sparrow,** *Hirundo bicolor.*
26. **Whippoorwill,** *Caprimulgis vociferus.*
27. **Chewink,** *Fringilla erythrophthalma.*
28. **Chickadee,** *Parus palustris.*
29. **Golden Robin,** *Icterus Baltimore.*
30. **Green Warbler.** *Sylvia virens.*
31. **Quail,** *Perdix Virginiana.*
32. **Skylark** (caged). Sent me by Mr. Flagg.

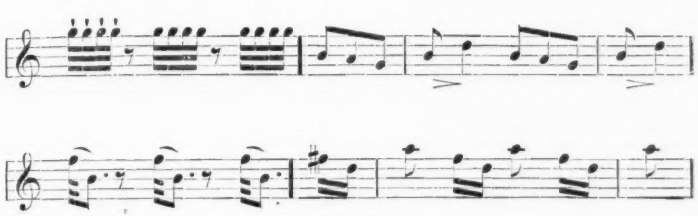
"My Garden," by Alfred Smee. London, 1872.

33. **Reed Warbler.**
34. **Thrush.**
35. **Blackbird.**
36. **Baltimore Oriole.** Call and reply. *Harpers' Mag.*, Sept., '76.
37. **Golden Oriole,** *Oriolus galbula* of Australia. *Science Gossip,* April, 1878.
38. **California Meadow Lark,** *Sturnella neglecta.* Three songs kindly given me by a gentleman familiar with music.
39. **Vesper Mouse,** *Hesperomys cognatus.*
40. **Vesper Mouse,** *Hesperomys cognatus.*

The two above songs, 39 the Wheel Song, 40 the Grand Roll, are given by Rev. S. Lockwood, AMERICAN NATURALIST, Vol. v, '71, p. 764.

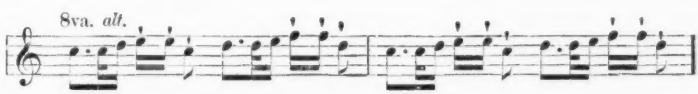
1. OVERTONES OF C.

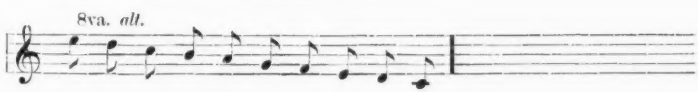


2. LARK.

3. NIGHTINGALE.

4. ROBIN.

5. BLACKCAP



6. WILLOW WARBLER.

7. YELLOW HAMMER.

8. RING PLOVER.

9. PEEWILL.

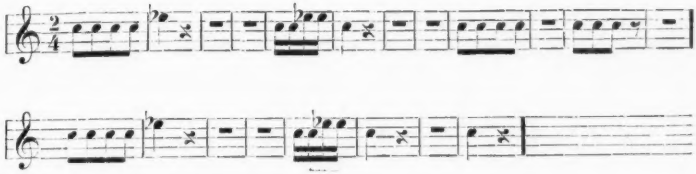
10. OYSTER-CATCHER.

11. LITTLE RING PLOVER.

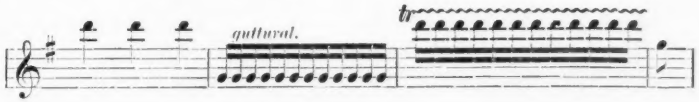
12. WHIMBREL.

13. CURLEW.

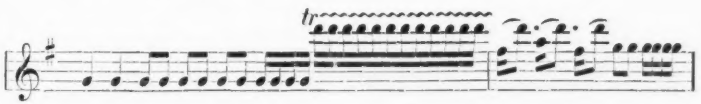
14. DULIN.

15. SWAN.

16. *a* SONG SPARROW.

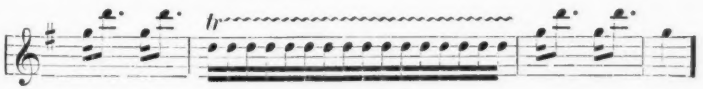
17. *b* SONG SPARROW.



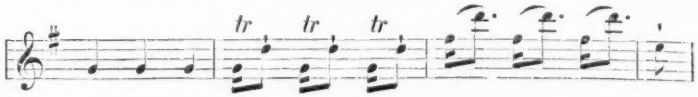
18. *c* SONG SPARROW.



19. *d* SONG SPARROW.



20. *e* SONG SPARROW.

21. *f* SONG SPARROW.

22. *g* SONG SPARROW.

23. PEABODY BIRD.

24. VIREO.

25. WOOD SPARROW.

26. WHIPPOORWILL.

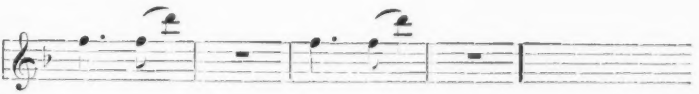
27. CHEWINK.

28. CHICKADEE.

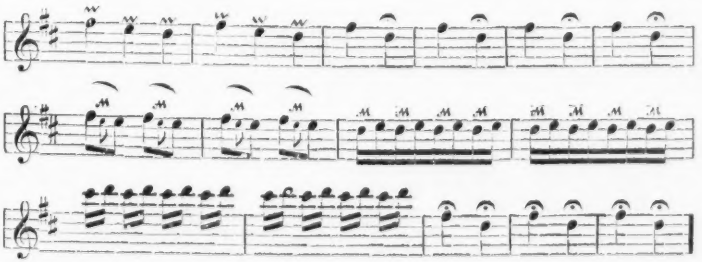
29. GOLDEN ROBIN.

30. GREEN WARBLER.

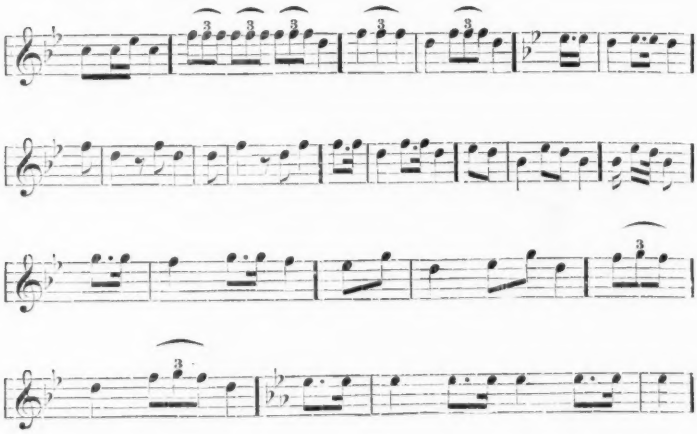
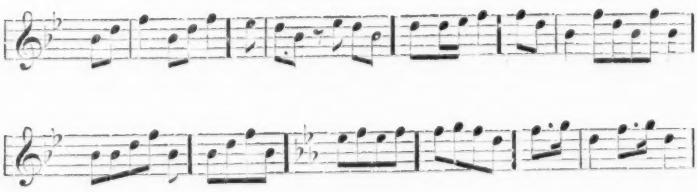
31. QUAIL.



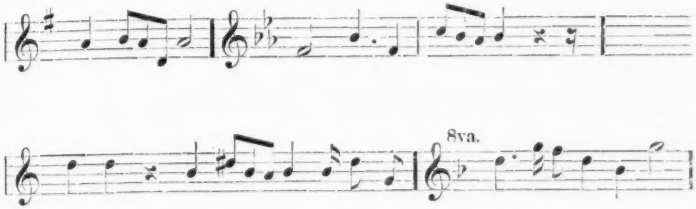
32. SKYLARK.

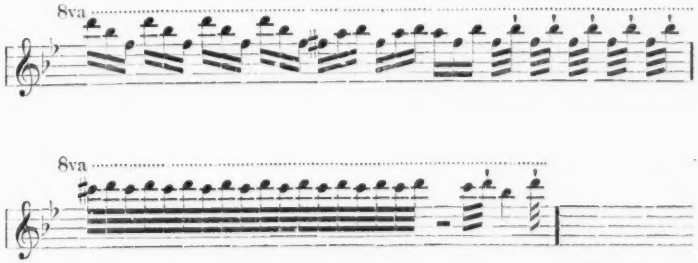


33. REED WARBLER.

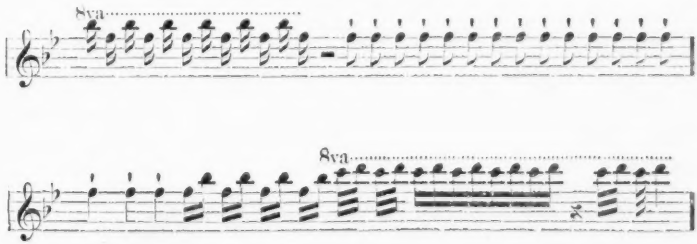
34. THRUSH.

35. BLACKBIRD.

36. BALTIMORE ORIOLE.

37. GOLDEN ORIOLE.

38. CALIFORNIA MEADOW LARK.

39. VESPER MOUSE.—WHEEL SONG.



40. VESPER MOUSE.—GRAND ROLL.



THE ARTIFICIAL MOUNDS OF THE ISLAND OF MARAJÓ, BRAZIL.[1]

BY ORVILLE A. DERBY.

Of all the localities in Brazil where the remains of ancient Indian tribes have been found, the Island of Marajó is the most interesting to the archæologist. Whether the race at this point was a superior one, or whether the conditions under which they lived were more favorable, it is certain that the ancient inhabitants of Marajó, or at least a portion of them, made greater advancement toward civilization than any other of the aboriginal tribes, having excelled in the arts those of every other part of Brazil, so far as we know to-day. In addition to shell-heaps and stone implements, similar to those existing in nearly all the provinces of Brazil, there are found at Marajó antiquities whose characters are quite peculiar to that locality and indicate superiority. I refer to the artificial mounds and the objects they contain, of which I propose to give a brief description.

Marajó, like all the region about the mouth of the Amazonas, is very low, and excepting a small tract in the east, is so slightly elevated above the level of the river, that in the winter it becomes changed into a large lake. Over all its expanse there is not a single natural elevation that might be called a hill, the portions not subject to overflow, being very gentle undulations of the surface, having a height of only a few metres above the surface of the water. As explained by its indefatigable explorer, Dr. S. Ferreira Penna, of Pará, the island may be divided into two nearly equal parts; the western, covered with forests in which abounds the India rubber tree, and the eastern, consisting of plains. It is the eastern part that concerns us now.

The plains being covered with a heavy growth of rich grass, constitute a good grazing ground, and are thus well suited to the raising of cattle, which is to-day almost their only industry.

The farmers have, however, to contend with many difficulties, due in part to the structure of the island. Every year many

[1] Several of the Museums of this country possess collections of pottery from Marajó, procured either by the late Professor Hartt, or by others; but up to this time no accurate account of the region whence they were obtained, has been published. The following translation of a short article, descriptive of this interesting island, which appeared in the Vulgarisador of Rio de Janeiro, September 22d, 1877, may thus prove acceptable to American archæologists.—RICHARD RATHBUN.

cattle are drowned in the lowlands, or fall victims to the alligators, and, from time to time, a more severe winter than usual deprives them of fodder, and occasions severe losses. Another and more important inconvenience arises from the impossibility of retaining in good condition a sufficient number of horses for farm work. Formerly horses thrived so well on the island that they came to take entire possession of the grazing grounds, forming a serious impediment to the industry of cattle-raising, and about forty years ago the farmers killed them by thousands for the sake of their hides. To-day horses are so expensive and their preservation so difficult that they are only in use where it is absolutely impossible to dispense with them. For ordinary service, and even for traveling, oxen are used, and, upon one occasion, I witnessed a troop of horses being driven to their enclosure by herdsmen mounted on oxen.

Near the centre of the island, in the midst of the plains, is a lake called Arary, out of which flows a river bearing the same name. Other important rivers are, the Igarapé-grande, which empties at the south-east part of the island, and the Anajús, which rises a little to the west of lake Arary, and, crossing the forests of the western side, receives, before leaving the plains, the tributaries Camutins and Moçoes. On the margins of all these rivers artificial mounds exist, but only those of lake Arary and the Camutins have been examined. Those which I shall now describe may be taken as types.

The best known mound is situated by the side of lake Arary, and in the winter becomes transformed into an island called the Island of Pacoval. In shape it is nearly oval, having a length of one hundred and fifty metres, a breadth of seventy metres, and a height of five metres above the water of the winter's overflow, which covers all the neighborhood for many miles around.

On one side of the island, exposed to the action of the waves, is a small cliff, in which the structure of the mound is displayed, and where it is seen that even to its base the earth is filled with pottery and ashes, proving the artificial origin of the mound. The waves have excavated very extensively into it, and the beach below is covered with the fragments of pottery. The mound being thickly wooded, the objects lying near the surface have been much broken up by the roots of the trees, but at a greater depth they are preserved in perfect condition. Several other lo-

calities on the shores of the lake have yielded a similar kind of pottery, but these places have not been investigated.

About six or seven leagues to the west of Arary, on the banks of the Camutins, there exists another well-known group of mounds, and a league farther are over fifteen others of large and small size. The plain is here also very low and subject to inundations, the greatest natural elevations not rising more than one or two metres above the water during the rainy season. A narrow strip of forest usually borders the margin of the river where the mounds, also wooded, are generally encountered; there are, however, other mounds situated upon the plain. The principal mound of the Camutins, known by the same name, is a veritable hill, having a height of fifteen metres above the plain, and with its sides so steeply inclined as to render their ascent on horse-back quite difficult. The outline of the mound is elliptical, its length being two hundred and ten metres, and its breadth at the base about eighty metres; but at the summit it is much narrower. The sides are furrowed by the rain which commences to excavate in holes made for the purpose of procuring *iguacabas*, which are in great demand as receptacles for farinha. In these furrows the earth is seen to be full of pottery and ashes as at Pacoval. As a stronger evidence of the artificial origin of the mound there is found near it a large excavation, similar to those sometimes formed in rail-road grading, and from which, without doubt was obtained the material for constructing the mounds. This excavation is on the opposite side of the river, and near it is another mound almost equal in size to that of Camutins. A few hundred metres below the mound of Camutins, on the same side of the river, is a third mound of less height, but broader and probably longer. This last is situated in a bend of the river, being surrounded by water on three sides.

These three mounds all extend in different directions, indicating that their position is without significance. They all have a more or less elliptical or oval form, but this seems to have been accidental, as there is no evidence that they were constructed according to any definite plan. It is quite different with the North American mounds, which in other respects closely resemble those of Brazil. In the former country they often assume the outline of a geometrical figure or of some animal.

According to the statements of the inhabitants there are in the

upper part of the river ten or twelve mounds of smaller size than the above. Still others exist on the margins of the Anajús, Moçoes and Igarapé-grande, and also in various parts of the plains, distant from any river.

From what has been said it is evident that the mounds of Marajó were the work of man, and that too of an exceedingly industrious race. For what purpose were they built—for defense, as dwelling places, or as cemeteries for the dead? They were probably intended for all these. They were primarily localities for living upon, elevated as much to escape inundation as to afford a better means of defense against enemies. That they were also used for interment is proved by the number of burial urns with skeletons which they contain. The remains of fire and of an abundance of pottery for domestic use indicate as well that they were places of habitation. It is likely that they were the sites of fortified villages, occupied by a tribe holding to the custom, so common among Brazilian Indians, of burying the dead inside the house.

I will now pass to a consideration of the objects found in the mounds; these consist of stone implements and pottery. The former are not common and do not differ notably in shape from those of other localities; they are well polished and made of diorite, a kind of stone which is not found on Marajó, nor at any near locality on the main-land.

Pottery exists in the greatest abundance, and is as noteworthy for its superior make as for the beauty and perfection of form and ornamentation which it displays. Of the majority of objects made by prehistoric man, it may be said that they are curious and interesting, but devoid of taste; that is, they do not gratify our tastes, perfected and purified by centuries of culture and art. Among the vases of Marajó, however, are some that compare very favorably with those of the ancient Greeks and Etruscans in symmetry and elegance of form, as well as in the relief and high grade of their decorations. The ancient inhabitants of Marajó were truly masters in ceramic art.

Considering that the aboriginal mode of making an earthenware pot was to coil up a long strip of clay—and of this fact we have ample proof in the mounds we are describing—it is wonderful to behold a pot thus constructed, measuring almost a metre in diameter, made perfectly symmetrical. This, together with the regularity and perfection of the lines of ornament,

demonstrates the great experience and culture of the maker. The ornaments encountered are naturally divided into three classes—those in relief, the engraved and the painted. The first kind is found upon idols and trinkets, and upon the sides of vessels, often forming handles by which they can be lifted. They are made by the hand, of soft clay, and generally rudely represent the human figure or that of some animal.

The engraved and painted ornaments, however, very seldom represent natural objects, and when they do, it is in a very conventional way, rendering it difficult to interpret them. They are usually of a purely æsthetic character, and include the fret, the cross and other styles very well known in art.

From some of the primitive forms has been worked out an exceedingly interesting series of modifications, from which arises the greatest value of the antiquities of Marajó. It is evident that we have there vestiges of a savage race that had entered upon the first rudiments of art, and advanced so little that it is possible now from their relics to trace each step in the early development of art. As the study of embryology has solved many difficult questions in zoölogy, so has the study of art here in the embryo explained important points in the general history of art.

Prof. Hartt has thoroughly investigated this subject, and has arrived at very important conclusions regarding it. A single example will serve to explain the importance of this study. Ruskin and others have proved that many of the complex designs of architecture and the other arts are evolved from the fret, but no one has carried the analysis farther. Now the pottery of Marajó comes in to complete the series, by showing that this fret originated from straight lines, which the savage, like a child, uses in his first attempts at ornamenting.

I am unable within the limits of this paper to discuss this exceedingly interesting subject further. It simply remains for me to add a few words respecting the uses of these various objects, that an idea may be obtained of the customs and the mode of thought of this ancient people. Some of the objects were doubtless idols, and indicate a form of religious belief to have existed among them; others seem to be trinkets or objects made as pastimes; others ornaments for the dress or person; while others still were articles of domestic use, and even these last were carefully ornamented. Finally, the largest and most elaborate of all were burial urns, sometimes of broad dimensions,

but always so constricted at the mouth as to admit only disjointed bones, deprived of their flesh. In these are encountered human remains, unfortunately, however, so reduced to powder that it is impossible to determine the physical characters of the race.

In conclusion, I can safely affirm, that even to-day it is very hard to find on the Amazonas proofs of greater industry than that furnished by these mounds, or a higher appreciation of the beautiful than is manifested by the ornamentation of the pottery of the ancient inhabitants of Marajó.

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NATIVE BITUMENS AND THE PITCH LAKE OF TRINIDAD.

BY W. O. CROSBY.

MINERAL pitch and the most of the native bitumens have been known from very early times. Among the ancient writers we find many statements indicating not only a knowledge but a practical use of these substances; and it is known that asphaltum was applied to architectural purposes more than four thousand years ago. That this substance was held in high estimation may be inferred from its being ranked by these writers among the best building materials of those ages, and from its application to structures requiring great solidity and permanence.

It is mentioned at several places in the Bible under the names of *slime* and *pitch*: Noah, in building the ark, being commanded to "pitch it within and without with pitch," while we read that the bulrush ark of the infant Moses was "daubed with slime and with pitch." Herodotus says it was used as a cement in building the strong walls of Babylon, large quantities being brought down to the Euphrates by the small river Is. These fountains of Is, celebrated as having attracted the attention of Alexander the Great, Trojan and Julian, still continue to pour out inexhaustible supplies. The same author describes the mode of obtaining solid bitumen and petroleum from a spring near Anderica, on one of the Ionian islands, and of separating them from each other and from foreign substances. This spring is flowing there to-day.

Diodorus Siculus and Josephus noticed the bitumen of the Dead sea, its use in medicine and in coating ships; its importation into Egypt; and its being there used with aromatic spices for the purpose of embalming bodies, which it preserved from putrefaction.

In their structures, the Romans directed much attention to solidity and permanence, and of course endeavored to select what were considered the most useful and durable materials. That these materials were often good is shown by the state of preservation of many of their works, and by the fact that their cement is scarcely equaled by any of modern time; and yet Vitruvius, a celebrated architect of the age of Augustus, speaks of bitumen as superior to every other kind of cement, and regrets its scarcity.

Notwithstanding the long time that native bitumens have been known, it is only within the present century that they have come to be extensively employed in the arts; and that geologists and chemists have reached definite conclusions concerning their origin, modes of occurrence, properties and relations. The prevalent notion that these substances are of rare and limited occurrence is entirely erroneous, for, as I shall presently show, the bitumens, taken as a class, are very widely and abundantly diffused through the crust of the earth. They are found in every quarter of the globe, and in every geological formation from the Cambrian to the present time. Their occasional association with what appear to be igneous rocks, has led some writers to infer that in their origin they are in some way connected with volcanic action. An explanation which, as Canon Kingsley has remarked, "savors somewhat of a 'bull;' for what a volcano could do to pitch, save to burn it up into coke and gases, it is difficult to see." When, as undoubtedly sometimes happens, the bore of a volcano passes through sedimentary strata holding bitumen or bituminous coal, it is easy to see how the connection of these substances with volcanic products may arise. But be their associations what they may, it has been definitely settled that in their origin the bitumens, like the coals, are always strictly organic. In every case they are the more or less transformed tissues of plants or animals.

Under the general name of bitumen are included both the liquid forms, petroleum and naphtha, and the solid varieties such as asphalt. Chemically considered, the bitumens are hydrocarbons the average composition being represented by the general formula $C_n H_{2n}$. The so-called bituminous coals, which, however, are destitute of true bitumen, are likewise hydrocarbons. These are distinguished from the bitumens by their smaller hydrogen ratio, analysis affording the general formula $C_n H_{2n-3}$, and

by the important facts that unlike many of the bitumens they are not liquid at ordinary temperatures, and unlike all the solid bitumens, are incapable of assuming the liquid state on the application of heat. The coals partake in a large degree of the nature of their chief constituent element, carbon, the most thoroughly solid substance known, distinguishing, as we should, solidity from density. In their entire insolubility, again, the coals are strongly contrasted with the bitumens, the latter class being all more or less soluble in liquids like benzole, sulphide of carbon, oil of turpentine and ether; and the less fluid bitumens, as asphalt, dissolving in the more fluid, naphtha-like, varieties.

Notwithstanding the general distinctness of these two great classes of native hydrocarbons, there is a point where they are not easily separated. Among the bitumens there are different degrees of fusibility and solubility, and a concomitant variation of the hydrogen ratio, presenting a regular gradation as we pass from naphtha with the maximum solubility and fusibility, and the largest proportion of hydrogen, through petroleum, mineral tar, and the various asphalts to idrialite, which, having the composition of bituminous coal, is fusible with difficulty, and only slightly soluble. From idrialite the passage is easy to true bituminous coal, and from this, as is well known, to anthracite. So that, as Dr. T. Sterry Hunt has stated it, "Anthracite or nearly pure carbon, on the one hand, and petroleum and naphtha, or carbon with a maximum of hydrogen, on the other, represent the two extremes of a series of which bituminous coals and asphalts are intermediate terms."

Following is a list of the more important members of this series, with their formulas, which have been calculated for twenty-four equivalents of carbon, to compare with the chief constituent of wood, cellulose:

Cellulose	$C_{24}\ H_{40}\ O_{20}$
Naphtha, Petroleum	$C_{24}\ H_{50}$
Mineral Tar	$C_{24}\ H_{18}$
Asphalt	varies from $C_{24}\ H_{44}\ O$ to $C_{24}\ H_{28}\ O$
Idrialite	$C_{24}\ H_{16}$
Bituminous coal	varies from $C_{24}\ H_{20}\ O_3$ to $C_{24}\ H_{16}\ O$
Anthracite	varies from $C_{24}\ H_{10}\ O$ to $C_{24}\ H_6\ O_{.5}$

A little study of these figures will make it clear that all these different hydrocarbons may be produced, theoretically at least, by removing from cellulose, which represents all woody matter, variable proportions of carbonic anhydride (CO_2), marsh gas (CH_4), and water (H_2O); and this is, in many cases, the course that nature pursues. Under ordinary conditions decaying wood is attacked by the oxygen of the air and burned up to carbonic anhydride, water and ashes as completely as if thrown into a furnace; but if kept out of contact with the atmosphere, as when lying beneath the water and mud of a marsh, or buried in deposits of sand or clay, the wood is still subject to decomposition, though the decay is of a very different order and much less complete. The oxygen is the most active element of the wood, and the first to leave; but it never goes alone, always taking with it some of the hydrogen in the form of water, or of carbon as carbonic anhydride. Afterwards other portions of the carbon and hydrogen unite and make their escape as the inflammable gaseous substance known as marsh gas. The presence of this gas in most swamps and marshes attests that nature's laboratory for the manufacture of coal and bitumen is still in operation. Both these species of decomposition, whether in the air or out of it, go on much more rapidly in the presence of heat; the first process being exemplified in every stove and furnace, and the second by the charcoal pit; for anthracite, the ultimate product of slow decomposition out of contact with the air, is simply a mineral charcoal.

A further inspection of our formulas will make it evident that to transform cellulose or wood into the average bitumen we must remove all the oxygen, some carbon and but little hydrogen; while for the conversion of vegetable matter into coal, the oxygen is less completely removed, and the hydrogen suffers much greater loss than the carbon. In the one case the escaping volatile products of the decomposition are mainly carbonic anhydride with some marsh gas; and in the other case the loss has occurred chiefly in the form of water, the carbon remaining largely intact. This is an important difference, and one which would be more obvious if our series included all the varieties of coal. The fact is this series is not a very natural one after all. It represents fairly well the changes resulting in the production of the different bitumens, viz: a complete abstraction of the oxygen and a gradual diminution of the hydrogen; but the coals are generated

by a gradual diminution of both elements, as the following series will show, the formulas being still computed for comparison with cellulose :

Peat and Brown coal	$C_{24}\ H_{20}\ O_{10}$
Lignite	$C_{24}\ H_{21}\ O_7$
Bituminous coal	varies from $C_{24}\ H_{20}\ O_3$ to $C_{24}\ H_{16}\ O$
Anthracite	varies from $C_{24}\ H_{10}\ O$ to $C_{24}\ H_6\ O_{.5}$

We are, then, to regard the coals and bitumens as forming two distinct but parallel series, in each of which there is an evident tendency to the reduction of organic matter to the state of pure carbon. Theoretically, at least, the final results, like the starting points, are chemically the same for the two series; but they are reached by different roads. Graphite, which is essentially pure carbon, is the final term of the coal series, and it is not improbable that *diamond* stands in the same relation to the bitumens, for Liebig has suggested that diamond is most probably formed by crystallization of carbon from a liquid hydrocarbon.

Oxygen and hydrogen exist in cellulose in the right proportions to form water, and the conversion of this substance into coal, as already stated, consists mainly in the union of these two elements. But we may now profitably notice some important observations of Principal Dawson, according to which we should no longer regard the ordinary vegetable fibre or cellulose composing the main body of plants as the principal source of coal, but certain epidermal tissues which differ from cellulose in being much poorer in oxygen. In other words, it is the bark mainly, and not the solid wood from which coal is formed. Dr. Hunt gives the composition of cork, which is a bark, as $C_{24}\ H_{37}\ O_7$. These cortical tissues, Dawson says, "are very little liable to decay, and resist, more than most other vegetable matters, aqueous infiltration, properties which have caused them to remain unchanged and resist the penetration of mineral substances more than other vegetable tissues. These qualities are well seen in the bark of our American white birch (*Betula alba*). It is no wonder that materials of this kind should constitute considerable portions of such vegetable accumulations as the beds of coal, and that when present in large proportion they should afford richly bituminous beds. All this agrees with the fact apparent on examina-

tion of common coal, that the greater number of its purest layers consist of the flattened bark of the sigillariæ and similar trees, just as any single flattened trunk imbedded in shale becomes a layer of pure coal. It also agrees with the fact that other layers of coal, and also the cannels and earthy coals, appear under the microscope to consist of finely comminuted particles, principally of epidermal tissues, not only of the fruits and spore-cases of plants, but also of their leaves and stems."

Every one, I think, must have observed, at some time, decaying logs, or better, stumps, of which little or nothing remains but a cylinder of bark, and this is apparently little altered. Dawson has found such hollow stumps in the coal formation, with abundant evidence that they had been the homes of animals, such as insects and reptiles. Such phenomena are the best illustrations of the superior resistance which this class of vegetable tissues offers to atmospheric action, a resistance undoubtedly due to the small proportion of oxygen which they contain; their composition, as Dr. Hunt has pointed out, approaching closer to resins and fats than to wood, and, "like these substances, they repel water, with which they are not easily moistened."

We have now traced to their origin in the vegetable kingdom all of the coals, so far as known, and many of the true bitumens. The notion is rapidly gaining ground among geologists, however, that the bitumens, especially the lighter and more fluid forms, such as petroleum and naphtha, are largely of animal origin. This view, for the development of which we are mainly indebted to Dr. T. Sterry Hunt, is based upon the following general considerations: (1) Animal tissues, the average chemical composition, but not the molecular structure, of which may be represented by the formula $C_{24}\ H_{38}\ N_6\ O_4$, approaches even more nearly than epidermal vegetable tissues to the composition of bitumens. (2) Although, as a rule, eminently unstable compounds, subject, under ordinary circumstances, to rapid and complete decomposition; yet we have good reason to believe that there are vast regions where the conditions are not only favorable for, but must necessitate, that slow and partial decay resulting in the formation of bituminous substances. The regions referred to are the depths of the ocean. Recent researches have shown, contrary to the old idea, that the deep sea holds an abundant fauna. All grades of animal life, from the highest to the lowest, have need

of a constant supply of oxygen. Now on the land, vegetation is constantly returning to the air the oxygen consumed by animals, but in the abysses of the ocean vegetable life is scarce or wanting, and hence it must result that over these greater than continental areas countless myriads of animals are living habitually on short rations of oxygen, and in water well charged with carbonic anhydride, the product of animal respiration. As a consequence, when these animals die their tissues do not find the oxygen essential for their perfect decomposition, and in the course of time become buried, in a half decayed state, in the ever increasing sediments of the ocean floor. The same thing must happen to animals living in higher bathymetric zones, all the way to the surface, whose bodies sink to the bottom after death; they yield a little ammonia and carbonic anhydride, and then pass into the comparatively stable condition of a liquid or solid bitumen. During the lapse of ages these sediments, rich in organic matter, will be consolidated into limestones and slates, and at a later period may be elevated to form new land; a process which has been many times repeated in the past. (3) For, as geologists well know, rocks corresponding to those just described are of very frequent and extensive occurrence among the formations now exposed to their observation.

Petroleum is usually associated with salt, the same well often affording both oil and a strong brine; a fact very suggestive of the marine origin of the petroleum. While the disagreeable smell of some oleiferous limestones is probably due, as remarked by Newberry, to the animal origin of the oil.

The capability which the so-called bituminous coals possess of yielding, by a process known to chemists as destructive distillation, various liquid and gaseous hydrocarbons, some of which resemble petroleum, a property common to most substances of organic origin, has not only led to their being erroneously regarded as bituminiferous, but many geologists have inferred that we have here a clew to the origin of the vast reservoirs of petroleum known to exist in this and other countries, and which have of late years been tapped with such astonishing results. Anthracite is undoubtedly a species of natural coke, produced when ordinary bituminous coal loses its volatile ingredients; its general mode of occurrence and geological relations prove this. But is nature's mode of making coke strictly analogous to what

goes on in the retorts of the gas works? Probably not. We have every reason to believe that the natural process is a very gradual one, and that the volatile products are all gaseous. In every bituminous coal mine in the world the two permanent gases, carbonic anhydride and marsh gas—the deadly choke-damp and fire-damp of the miners, are constantly escaping from the coal, but unaccompanied by any oily, petroleum-like liquid. This action, sufficiently long continued, must result in the production of anthracite, and that it has so resulted is evidenced by the fact that the rocks lying above the great deposits of anthracite are quite free from the liquid bitumens we should otherwise expect to find there. The fact is, that in Pennsylvania the anthracite is in one end of the State and the petroleum in the other; and, moreover, the petroleum is obtained from a formation below the Carboniferous, to which the coal belongs. Its origin is sometimes referred to the carbonaceous shales or pyroschists of the underlying Hamilton beds; but these, like the coals, are found, on examination, not to contain any bitumen, and like the bituminous coals, they still retain perfectly the power of yielding bitumens when sufficiently heated. Beyond the limits of Pennsylvania the general facts are the same, and nowhere is there any evidence proving a connection of the petroleum with the coals or pyrochists. Petroleum is generally obtained from wells sunk in sandstone or slate. In some cases it is probably indigenous in these, but usually it has been forced up by hydrostatic pressure or sponge-like absorption from oleiferous limestones. There are several extensive formations of these limestones in Eastern North America, and geologists are only beginning to appreciate their abundance and richness. The oil is found filling the pores and cavities of fossil shells and corals, and saturating the entire substance of the limestone, the evidence being plain that it is indigenous in this position and has not been introduced into the limestone subsequent to the formation of the latter. Dr. Hunt has made a quantitative determination of the petroleum in a limestone of Niagara age occurring near Chicago, with the following almost incredible result: Although the formation has a thickness of only thirty-five feet, yet in each square mile it must contain not less than "seven and three quarter millions of barrels of petroleum." He says further, "The total produce of the great Pennsylvania oil region for the ten years from 1860 to 1870 is

estimated at twenty-eight millions of barrels of petroleum, or less than would be contained in four square miles of the oil-bearing limestone formation of Chicago."

As a rule limestone is too massive and close grained to permit the oil to flow freely through it to supply wells sunk in this rock; but overlying sandstones gradually soak up the oil, and its accumulation along the crests of anticlinal arches in the latter rock is due to the presence of water in the strata, which, being the heavier liquid, forces the oil to the top. The richest wells are those which tap large bodies of oil contained in the great fissures and cavities which, as geologists well know, usually accompany an anticlinal fold of the strata. Very often these subterranean chambers are filled partly with oil and partly with gas, and the latter serves a useful purpose in forcing the former to the surface. This gas is derived from the oil itself, and if the situation of the fissure or the texture of the rock are such that the gas can escape, its formation will continue until, in some cases at least, the petroleum is reduced to a thick viscid or even solid condition. It is by a similar but more rapid fractional distillation that the petroleum is refined for illuminating purposes, the solid residue being chiefly the substance paraffine. The fissures filled with solidified or inspissated petroleum are not wholly theoretical, for several have been discovered, which, through some accident of erosion or faulting of the strata, are now exposed on the surface. The most noted of these is in New Brunswick, the material occupying the fissure being the famous and valuable mineral, albertite. This is a jet-black lustrous substance intermediate in physical characters between bituminous coal and asphaltum, though chemically it is much nearer the latter than the former, affording the formula $C_{24}\ H_{32}\ O_{1.6}$. This deposit bears no resemblance to a true coal bed, but fills a large irregular crevice cutting across the strata. The enclosing shales are rich in the remains of fish, and so bituminous as to be visibly oily, and to "sustain a fire without the aid of other fuel." The grahamite of West Virginia is a substance closely resembling albertite and occurring in a similar fissure or crevice. The same phenomena, on a smaller scale, are many times repeated in Canada, in the vicinity of Quebec and elsewhere.

Whenever petroleum is exposed to the air for any length of time, as when it slowly exudes from the rocks, forming petroleum

springs, it is likely, in a manner similar to that just described, to lose its more volatile ingredients and become semi-solid like mineral tar, or solid like asphalt. And so it happens that many of the smaller deposits of asphaltum in this and other countries are simply dried up petroleum, and are of animal origin. The great deposits of the globe, however, those which constitute the principal source of the asphaltum employed in the arts, do not appear to have been formed in this way; but have, in most cases at least, been derived directly, after the manner of coal, as already explained, from decaying vegetation.

Extensive deposits of asphaltum, such as that for which the island of Trinidad is celebrated, are commonly regarded as something exceptional, something out of the natural order, a freak of nature. This notion is without foundation in facts, for asphaltic substances are not only widely disseminated, as already stated, but in not a few localities, which form a zone girdling the earth, they are accumulated in such vast abundance as to ensure an unfailing supply for man's purposes for all time to come.

A list of the localities where asphaltum is especially abundant may further enforce this view, these are: Cuba, several of the Windward islands, especially Trinidad and Barbadoes, the Caribbean shore of South America, particularly the province of Maracaybo, Caxitambo and Berengela in Peru, where are lakes of asphalt similar to that on Trinidad; Mexico, Texas and California in North America, Persia and Arabia, Palestine on the shores of the Dead sea and on Mount Lebanon, Ionian islands, France, Switzerland and Portugal, It is a curious fact that the asphalts are confined almost wholly to tropical and sub-tropical regions. There appears to be in low latitudes some general climatic or other condition which has in many cases determined the conversion of vegetable matter into bitumen instead of coal.

The largest deposit in Europe is probably that in the Val-de-Travers, Neufchatel, Switzerland, which has been worked for more than one hundred and fifty years. This occurs in rocks of Cretaceous age; but as a rule the great masses of asphalt are found in connection with Tertiary strata. This is the geological position in Trinidad, Barbadoes, Peru and other points in South America and in California. Trinidad is composed chiefly of Tertiary and Secondary beds, the former predominating; but toward the north the island otherwise quite low, is bordered by a bold

range of mountains, a detached link of the great littoral Cordillera of Venezuela. These are composed of ancient crystalline strata, and stand like a wall between the Tertiary plain on the south and the Caribbean sea, and the long chain of volcanic islands on the north. There is scarcely a trace of true volcanic action observable in Trinidad, the hot mud springs—the so-called mud volcanoes—hardly coming in that category. They may be classed as hydro-thermal but not as igneous phenomena. I have also seen little or no evidence of volcanic action during the past epochs in the history of the island; and the frequent severe earthquake shocks of the regions on the west and north are very rarely felt with destructive force in this favored isle.

Asphaltum, usually accompanied by mineral tar and petroleum, occurs at many points on Trinidad and also on the adjacent main. But the largest and most interesting deposit, not only of this region but of the world, is that known as the Pitch Lake. This is on Point La Brea (La Brea being Spanish for *the pitch*), in the south-western part of the island, and one mile from the Gulf of Paria. The topography of the country about the lake is extremely simple; from three sides—north, west and south—the land slopes gradually upward from the sea to the surface of the lake, which lies one hundred and thirty-eight feet above the gulf; while on the east the land is slightly higher than the lake. In other words, the Pitch Lake is on the faintly-marked shoulder of a broad, low ridge which, projecting into the gulf of Paria, forms the peninsula or promontory of La Brea. Contrary to all topographic laws and precedents, this so-called lake is not in a valley, but on a hill-top. I have already denied the existence, both past and present, of volcanic phenomena in this region, and yet the situation of this remarkable deposit of asphalt is very much as if the broad-mouthed crater of a low-lying volcano were filled to the brim with this material. I say filled to the brim, because on the three sides named above, the surface of the pitch is even with the brow of the hill, and more so, for at many points the viscous substance is constantly overflowing and moving seaward, after the manner of very sluggish lava streams. The motion is extremely slow, the pitch, where it issues from the lake, being a brittle solid. The moving masses present curved lines and surfaces, which are convex downwards; and Kingsley has very aptly likened these streams of asphalt to glaciers, the lake representing a *mer de*

glace. The asphalt becomes harder the longer it is exposed to the air and the sun, through loss of its volatile ingredients, and consequently the downward progress of the "black glaciers" must sooner or later be checked, if not entirely stopped. It seems impossible to determine the extent of the overflow, for although the entire slope from the lake to the sea appears as a continuous stratum of pitch, the soil being everywhere very thin or entirely wanting, yet it is probable, as pointed out by Messrs. Wall and Sawkins,[1] that the most of this superficial sheet has exuded from the asphaltic sandstone—a sandrock supersaturated with asphaltum—which forms the rocky basis of that portion of the ridge where the free asphalt is found. The area covered or underlaid by this mantle of pitch is estimated at 3000 acres.

The bitumen is certainly not injurious to plant life, for the scanty soil covering the pitch, and consisting largely of that material in a pulverulent state, supports a luxuriant vegetation. The village of La Brea, on the shore, with the boiling houses where the asphalt is refined, rests on the pitch; and the inhabitants complain that their houses are liable to be thrown out of level by the rising or sinking of the tarry foundations. It seems as if everything superficial here, vegetation, houses, roads, etc., must be slowly but surely drifting toward the sea.

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There are some twenty or more patches on the lake, five to fifteen yards in diameter where soil has collected and vegetation —trees, shrubs and grasses—has gained a foothold, forming green islands or oases. The surface presents many small dome-shaped swellings or protuberances, from an inch to a foot in diameter; these pitch bubbles are always hollow, and contain traces of the lighter portions of vegetation in a half decayed state, the thin covering appearing to have been raised by gases given off from the decomposing leaves and twigs, or liberated by the sun's heat from the pitch itself. Excavations made in the pitch show that below the surface these cavities or vesicles are exceedingly numerous; they are usually almond-shaped or ellipsoidal, being

flattened by pressure, and though always the result of gaseous expansion, are commonly filled with water; in fact the entire mass of the pitch is saturated with water, so that even where quite soft it will not soil the hands, because the water oozes out and prevents adhesion. The earthy impurities of the pitch also assist in rendering untrue, in this instance, the old proverb that one cannot touch pitch without being defiled.

The pitch is mined or quarried by excavating areas thirty or forty feet square to a depth of two to four feet. As soon as the work ceases on one of these cellar-like excavations the surrounding asphalt, seeking to restore the equilibrium, begins to obliterate it, the walls not closing in perceptibly but the bottom rising up, and in a few days no trace of the opening remains. This is only one of many indications of greater fluidity below the surface. The plasticity of the pitch is evidently due to the oily matter which it contains, and not in any sensible degree to the temperature. Hardened bitumen, it is true, may be fused by the application of sufficient heat, but that which is naturally fluid remains so at all ordinary temperatures. As already explained, when the asphalt is exposed to the air it becomes solid through loss of its volatile ingredients. Towards the center of the lake are several detached areas, a rod or two in breadth, which are softer than the rest of the surface, and yield under the feet, "so that on standing a few minutes one feels that he is gradually settling down, and in the course of ten or fifteen minutes he may find himself ankle deep." "But," as Mr. Manross[1] truly says, "in no place is it possible to form those bowl-like depressions round the observer described by former travelers." Nor is it probable that Kingsley is right in saying, "No doubt there are spots where, if a man stayed long enough, he would be slowly and horribly engulfed." The inferior density of the human body would prevent its submergence even if the pitch were quite fluid.

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The water filling the channels is clear, pure rainwater, and contains numbers of small fishes, water beetles and other aquatic animals. It has been observed escaping from the canals at eight nearly equidistant points on the circumference of the lake.

Several hypotheses have been proposed to account for the peculiar structure of the lake. Mr. Manross says, "The channels are produced and maintained by the following singular process: Each of the many hundred areas into which the lake is divided possesses an independent revolving motion in this wise: In the center of the area the pitch is constantly rising up *en masse*, displacing that which previously occupied the center, and forcing it towards the circumference. The surface becomes covered with concentric wrinkles and the interior structure somewhat laminated. Where the edge of such an expanding area meets that of the adjoining one the pitch rolls under to be thrown up again in the center at some future period. It is difficult to conceive of a

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motion like this going on in a material almost of stony hardness, but that such a revolution is constantly taking place over the entire surface of this black lake cannot be doubted. The conclusion then to which a close observation leads us in regard to the present condition of this singular lake is, not that it has suddenly cooled down from a boiling state as heretofore described, but that solid as the material is, it is still boiling, although with an indefinitely slow motion. As the descent of the glaciers may be considered the slowest instance of flowing in nature, so the revolutions of the scarcely less solid bitumen of this lake may be set down as the slowest example of ebullition."

Messrs. Wall and Sawkins, on the contrary, deny the existence of the revolving motion, and consider that each of the areas represents a center of emission where the asphalt has issued from the underlying sandstone, "and gradually advanced until the material from the surrounding foci being encountered, further progression was impeded, and the accumulation proceeded in the vertical in place of the horizontal direction." But the present level of the lake has evidently been maintained for ages, and consequently it is difficult to see why, if this view is correct, the asphaltic bosses have not flattened out and closed up the water channels.

Neither of these views can be regarded as entirely satisfactory. Mr. Manross is undoubtedly right as regards the circulation, though in error as to its cause. He finds unique and conclusive evidence of the revolving process in "numerous pieces of wood which being involved in the pitch are constantly coming to the surface. They are often several feet in length and five or six inches in diameter. On reaching the surface they generally assume an upright position, one end being detained in the pitch while the other is elevated by the lifting of the middle. They may be seen at frequent intervals all over the lake, standing up to the height of two or even three feet. They look like stumps of trees protruding through the pitch, but their *parvenu* character is curiously betrayed by a ragged cap of pitch which invariably covers the top and hangs down like hounds' ears on either side." These fragments of wood are of the same recent origin as the leaves and twigs contained in the vesicles of the pitch. From the surrounding forest or the green islands of the lake itself, they have found their way into the water channels,

become water-logged, sunk to the bottom and been drawn down by the ever-revolving pitch.

In one case at least within my observation, a recently detached portion of one of the islands of vegetation afforded incontestable evidence of a horizontal movement of the subjacent pitch to the extent of several feet.

According to the present writer, the true cause of the revolving motion of the pitch, and of the structure resulting therefrom, is found in a fact pointed out by Wall and Sawkins, but not insisted upon or fully appreciated by them, viz: the great diurnal range in the temperature of the surface of the pitch. On unclouded days the asphalt attains an average temperature of about 140° Fahr., and sinks during the night to 70° or 60°, suffering a variation of 70° to 80°, which must produce a considerable change of volume, especially if we consider the vesicular nature of the pitch and the quantity of water which it contains. This expansion will be superficial, and its chief tendency to extend the pitch horizontally. Where the pitch is covered by water it will not experience this alteration of volume. The courses of the water channels may have been determined originally by slight inequalities of the surface, holding shallow sheets of water, or drifting sand may have occupied these positions and served to protect the asphalt along these lines from the heat of the sun. The main point is that the protected areas would be forced downwards by the expansion of the unprotected areas, and this motion once established would continue without interruption until the contours of the present surface were developed.

Nocturnal radiation and consequent contraction could not undo the effect of the diurnal expansion, but the equilibrium would be and doubtless is maintained by the elevation of pitch from below in the center of the areas. The plastic pitch beneath the solid crust is sometimes forced upwards through the crevices in the bottom of the channels. One interesting example of this is described by Mr. Manross: "In one of the star-shaped pools of water, some five feet deep, a column of pitch had been forced perpendicularly up from the bottom. On reaching the surface of the water it had expanded into a sort of center-table about four feet in diameter, but without touching the sides of the pool. The stem was about a foot in diameter. I leaped out upon this table and found that it not only sustained my weight but the elasticity of the stem enabled me to rock it from side to side. Pieces torn

from the edge of this table sank readily, showing that it had been raised by pressure and not by its buoyancy."

No soundings have ever been made in this lake and its depth is unknown. The thickness of the deposit is of course a factor of the first importance in determining whether the supply of asphalt from this locality is likely to prove practically inexhaustible in view of the steadily increasing demand for this material in the arts. According to Wall and Sawkins each foot in depth is equivalent to 158,400 tons, and they assume the maximum average depth at thirty feet, making the total supply 4,752,000 tons. Judging by the uniformity of the asphalt and the size of the revolving areas, the true mean depth must considerably exceed this estimate. It is believed that the pitch could be readily excavated to a depth of ten or fifteen feet, and from that level iron bars could probably be forced to the bottom and the true depth accurately ascertained. In considering the question of the probable permanence of the supply, it is important to remember that the material is doubtless still escaping from the underlying asphaltic sandstone, though perhaps very slowly.

As regards its origin, the lake is believed not to differ essentially from any of the patches of pitch scattered over the surrounding country except in this, that the form of the surface has been more favorable for its accumulation. It appears to be simply a large puddle of pitch, which has oozed out of the sandstone and collected in a basin-like depression in that rock.

The observations of Mr. Wall have placed the vegetable origin of this bitumen beyond question. The asphaltic sandrock is rich in vegetable remains, and it is possible to trace every step in the conversion of these into asphaltum, until the organic texture of the wood is entirely obliterated and pure bitumen results, the external form of the wood alone remaining.

The fact that the Island of Trinidad lies between a portion of the delta of the Orinoco and the sea, long ago led Sir Charles Lyell to adopt the view that the asphalt deposits of Trinidad, including the Pitch Lake, which is on the side of the Island towards the delta, represented the drift wood brought down by the Orinoco in past geological ages. But I believe he afterwards concluded that this explanation, like the wood itself, was rather far-fetched. For it can be proved that at the time (Miocene period) when these asphaltic beds were forming, the mouth of the Orinoco was some one hundred and fifty or two hundred miles further up stream than at present.

NOTES ON AN EXTENSIVE DEPOSIT OF OBSIDIAN IN THE YELLOWSTONE NATIONAL PARK.

BY WM. H. HOLMES.

CONSIDERABLE deposits of obsidian and obsidian porphyries had been observed in the national park previous to our visit in the summer of 1878, but no satisfactory exposures of the glassy varieties had been found. In October I had occasion to make examinations of a locality particularly rich in them, situated in the north-western part of the park, near the head of Obsidian or Alum creek, a tributary of the middle fork of Gardiner's river. The crumbling trachytes of this part of the park give, in general, a rounded and monotonous character to the topography. The slopes of the valleys are gentle excepting at points where the glassy rocks predominate.

In ascending Obsidian creek, by way of the newly-cut wagon road which connects Mammoth Hot Springs with the Geyser Basins, we pass first through broad meadows and parked forests. Farther on the valley narrows up and the timber becomes extremely dense. At a point about twelve miles above the junction of the creek with the main stream, there is a narrow gateway known as Obsidian cañon, through which the road and creek pass. From the east side of the valley a low promontory extends forward to the creek and breaks off in an abrupt nearly vertical wall, in which the obsidian rocks are exposed. The road approaches the cañon along the west side of the valley, and crosses to the east side at the lower end of the cañon; in order to avoid the swampy ground that borders the stream it has been carried across the steep débris slopes of the obsidian cliffs. For half a mile it is paved with glassy fragments and lined by huge angular masses of black and banded obsidian rock. From the upper border of the débris slope the vertical cliffs rise to the height of nearly two hundred feet. The lower half is composed of a heavy bed of black obsidian which exhibits some very fine pentagonal columns, somewhat irregularly arranged and frequently distorted, but with perfectly cut faces that glisten in the sunlight. The upper portion of the wall is composed of a much more obscurely columnar mass of impure spherulitic obsidian, the rude faces of the columns being often as much as ten or twelve feet across. To the right and left the columnar character becomes

less marked, both in the upper and lower part of the cliff, and farther out seems to be entirely lost, the glassy rocks grading into the gray sanidine trachytes and obsidian porphyries of the surrounding hills.

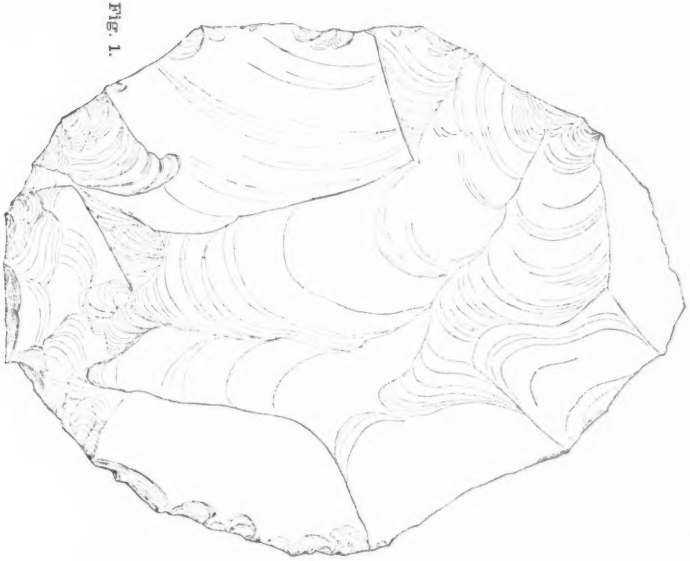
Extending upward from the edge of the promontory in a moderately gentle slope are four or five hundred feet of obsidian strata that exhibit some most interesting characters. There is no heavy mass of pure glassy rock, but a succession of irregular layers of a dozen or more varieties of spherulitic obsidian, obsidian porphyries and breccias. The colors of these rocks are exceedingly varied, the prevailing blacks giving way to reds, browns, greens and the richest possible marblings and mottlings.

One of the most striking characteristics of these rocks are the spherulitic concretions which occur to a greater or less extent in all the varieties. These bodies seem to prevail in the ashy-like bands or layers which, in the more compact mass toward the base, are frequently contorted, giving the rock the appearance of a banded and contorted gneiss. The ashy-appearing layers are probably composed of the same material as the concretions, since when we split the rock *with* the bands, the surfaces of the gray bands next the glassy layers are simply a connected or coalescent series of nodes or hemispheres which have the usual appearance of the more isolated concretions. Where the concretions are scattered throughout the glassy mass, they are globular or composed of a cluster of globes. They have, in most cases, a distinctly radiated structure, with not infrequently concentric layers near the surface. The interior is gray or pinkish-gray, and the surfaces, pinkish or flesh colored.

In the coarsely columnar part of the wall the spherulites are often a foot or more in diameter and appear much flattened and distorted. It is probable that these irregular forms are produced by the coalescence of a large number of smaller ones, as there are apparently many centers of radiation. Large beds of the rock seem to be made up almost wholly of the concretions, and where decomposed, a mass of coarsely cellular or honey-combed obsidian remains. The brecciated beds consist of an ashy matrix in which are imbedded angular fragments of every variety of the brilliantly-colored spherulitic and ordinary obsidians.

The collection of hand specimens made at this place is very complete, numbering upwards of three hundred. Their examina-

Fig. 1.



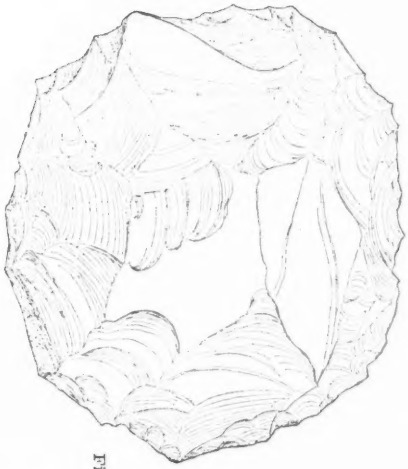


Fig. 3.

Fig. 2.

tion by specialists in petrography will doubtless develop many new and interesting features, as no equally rich deposit of similar rocks has heretofore been brought to their notice in this country.

Indian Implements.—It occurred to me, while making examinations at this point, that the various Indian tribes of the neighboring valleys had probably visited this locality for the purpose of procuring material for arrow-points and other implements. A finer mine could hardly be imagined, for inexhaustible supplies of the choicest obsidian, in flakes and fragments of most convenient shapes, cover the surface of the country for miles around.

Having climbed the promontory, I observed that an old but quite distinct trail passed along the brink of the ledge and descended the broken cliffs to the valley above and below. In the vicinity of the trail the glistening flakes proved to be more plentiful than elsewhere, and were also apparently gathered into heaps. After a short search a leaf-shaped implement of very fine workmanship was found; it is made of the black opaque obsidian, and is four inches in length, three inches in width and one-half an inch in thickness; an outline of this implement is given in Fig. 1. Having continued the search as long as the time at my command would permit, I was amply rewarded in the possession of ten more or less perfect implements. Three are leaf-shaped and nearly the same in size as the first specimen found, but imperfect from having been broken. One is somewhat pyramidal in shape, as shown in Fig. 2; the bottom is flat, the flaked surfaces extending from the base to the apex; it is two and a half inches in width and one and three-quarters in height, and is the only specimen in the collection that appears to have been in the least used; the sharp edge at the base is considerably worn; Fig. 3 is a top view of the same. Another specimen is triangular in shape with sides about three inches long; another is rectangular and about three inches wide by four in length, and still another is a rude oval; nearly all of these implements are imperfect, as if broken or unfinished. If we are to suppose that the great quantities of minute flakes are the fragments left from the manufacture of implements we must conclude that extensive supplies have been obtained here, but by what tribes or at what period it will be quite impossible to determine.

RECENT LITERATURE.

MACFARLANE'S GEOLOGISTS' TRAVELING HAND-BOOK.[1]—The design of this small octavo of two hundred and sixteen pages, which is well expressed in the title, is certainly novel. This is a distinctly new departure in geological literature; and it is surprising that it is so, since there has long been room for such a work. It supplies a want long experienced, for every geologically-minded traveler must have felt the need of a key or guide to the geology of the districts traversed. But the book is designed for the unscientific observer as well as for the professional geologist. In this connection the author says: "One object of the work is to teach persons not versed in geology something of this science during the tedious and unprofitable hours of traveling, without study, not as in a text book, but by pointing to the things themselves as seen at railway stations and through the windows of a railway car;" and it is not improbable that the chief value of the "Guide," as regards the interests of the science, will consist in the wider diffusion by right means of geological knowledge and interest which it will effect.

Forty pages in the first part of the book are devoted to brief but comprehensive descriptions, especially designed for unscientific travelers, of the different geological formations, beginning with the Eozoic, the divisions of which are those proposed by Dr. T. Sterry Hunt and the Canadian Geological Survey. The descriptions of these are from the pen of Dr. Hunt and are notable as constituting the first general account that has appeared in a popular work of those grand fragments of the material record of the earth's history which, whether we consider their volume or the length of time required for their formation, appear vastly more important than the corresponding divisions of the Palæozoic and later eras. From an economic point of view, too, the most of these primary Eozoic divisions are outranked by none of the more recent formations, except the Carboniferous. Following these descriptions are two tables of the geological formations, one by Prof. J. D. Dana similar to that in the second edition of his Manual, and the other by Dr. Hunt, which differs from Dana's chiefly in the divisions of the Eozoic and Cambrian. The former is principally followed in the subsequent portion of the work, which consists of one hundred and fifty-six pages of tables of railway stations, the railways being grouped according to States, while opposite the name of each station is the name of the formation occurring there, and in some cases the altitude above sea level. The nomenclature of the formations necessarily varies

[1] *The Geologists' Traveling Hand-Book.*—An American Geological Railway Guide, giving the geological formation at every railway station, with notes on interesting places on the routes, and a description of each of the formations. By JAMES MACFARLANE, Ph.D., with the coöperation of the State Geologists, and other scientific gentlemen. New York, D. Appleton & Co., 1879.

considerably in the different States, but a common number attached to them throughout the book, serves for their identification by whatever name they are called.

A majority of those having occasion to use this work, will probably regret the almost complete absence of references to palæontology and mineralogy, nothing being given in most cases beyond the mere name of the formation, with very rarely an allusion to its lithological character; so that we have here little more than a chronological guide. It is true the author tells us that to have included fossils, rocks and minerals in the scope of the work, would have made an unwieldly volume of what to be serviceable must be small; but this objection to fuller information appears less valid when we reflect that an addition of even fifty pages would not make the book inconveniently large, *i. e.*, it would still be smaller than many railway and tourists' guides, and that the characteristic fossils, rocks and minerals are not required for every station, but only for those points, comparatively few in number, where they are best developed and may be studied to best advantage; and then it would be quite unnecessary to name the fossils, except, perhaps, in a general way. That is, one usually likes to know, not only the name and extent of the formation he is traversing, but also the points along his route where its palæontologic, lithologic and other characters are most favorably exposed, as this will often determine the choice of a route and the stoppages to be made. To some extent the meagre information on these points contained in the tables is supplemented by foot notes; but these are copious only for New York, Pennsylvania and Virginia, while for the most of the States they are almost entirely wanting. The foot notes to the chapters on the Dominion of Canada and New England, for example, aggregate scarcely half a page, while for New York alone they amount to eight and one-half pages, and for Pennsylvania there are nearly six pages, and the great State of Ohio has not a single line.

On railroads where the stations are separated by short distances, the less important are sometimes omitted, but we are informed that this only occurs where the same formation is continuous across the break; a casual examination, however, shows that this precaution has not always been observed. The most important exception noticed is on the Boston and Albany railroad, in Massachusetts, where eight stations in succession are omitted between Brighton and South Framingham, although the two stations named are correctly marked as being on entirely distinct formations. Brighton and the five stations next to the west are on Cambrian, then come Grantville, Wellesby and Natick, on typical Huronian with a breadth of seven miles before we reach South Framingham, which is marked as Laurentian, though in the writer's view more probably Montalban.

Although the book is deemed susceptible of improvement in

the directions indicated, yet it contains a vast amount of valuable knowledge carefully tabulated, and is a highly creditable first step toward supplying a recognized want; and no traveling geologist —whether beginner, amateur, or professional—can afford to be without it. The binding is not all that could be desired for a work of this character, since the covers are neither stiff enough to resist bending, nor sufficiently flexible to bend without breaking.—*W. O. C.*

RECENT BOOKS AND PAMPHLETS.—Habit and Intelligence: a series of Essays on the Laws of Life and Mind. By Joseph John Murphy. 2d edition. Illustrated, thoroughly revised, and mostly re-written. 8vo, pp. 583. Macmillan & Co., London, 1879. From the author.

On the Annelida Chætopoda of the Virginian coast. By H. E. Webster. (Issued Jan., 1879, in advance of Vol. IX of Transactions of the Albany Institute.) 8vo, pp. 72, pls. I–XI. From the author.

Extracts from Letters and Notices of Eminent Scientific Men and Journals in Europe and America, respecting the United States Geological and Geographical Survey of the Territories. (Department of the Interior.) Under the direction of F. V. Hayden, Geologist-in-charge. 8vo, pp. 42. Washington, 1879.

The Animal, Vegetable and Mineral Kingdoms; or the Advantages to be derived from a study of "Natural History" in public and private schools. By Mrs. N. B. Walker. 8vo, pp. 18. Wilbur & Hastings, New York, 1879. From the authoress.

The Mesozoic Formation in Virginia. By Oswald J. Heinrich, Mining Engineer. (Ext. from Trans. Am. Ins. of Mining Engineers. Read at the Philadelphia meeting, Feb., 1878.) 8vo, pp. 48, with map. From the author.

The Physical History of the Triassic Formation of New Jersey and the Connecticut valley. By Israel C. Russell. (Ext. from Ann. N. Y. Acad. of Sciences, Vol. I, No. 8. 1878.) 8vo, pp. 35. From the author.

The Department of Physical Education and Hygiene in Amherst College. By Prof. Edward Hitchcock, M.D. 8vo, pp. 10. Boston, 1879. From the author.

Bulletin of the United States National Museum. No. 12—Contributions to North American Ichthyology. No. 3, A—On the Distribution of the Fishes of the Allegheny region of South Carolina, Georgia and Tennessee, with descriptions of new or little known species. By David S. Jordan and Alembert W. Brayton. B—A Synopsis of the family Catostomidæ. By David S. Jordan. (Published under the direction of the Smithsonian Institution.) 8vo, pp. 237. Washington, 1878. From the authors.

Description of a New Species of Dolabella from the Gulf of California, with remarks on other rare or little known species from the same region. By Robert E. C. Stearns. (Ext. from Proc. Phila. Acad. Nat. Sciences, 1878.) 8vo, pp. 395–401. From the author.

Scientific Relations of Sociology to Biology. By Prof. Joseph LeConte. 8vo, pp. 21. From the author.

Proceedings of the American Philosophical Society, held at Philadelphia, for Promoting Useful Knowledge. Vol. XVIII, July to Dec., 1878. No. 102. 8vo, pp. 120. From the society.

Correspondence about Water Supply, between James Haworth, Esq., his counsel, Mr. Rob. A. Parrish, Jr., and John W. Nystrom. 8vo, pp. 25. Philadelphia, 1879. From the author.

Remarks on Saurocephalus and on the species which have been referred to that genus. By E. T. Newton, Esq., F.G.S., H. M. Geol. Survey. (Ext. Quar. Jour. Geol. Soc., London, Nov., 1878.) 8vo, pp. 786–796. (Published Oct. 12, 1878.) From the author.

Notes from Private Practice. Is the bite of the Heterodon, or spreading adder, venomous? By J. Schneck, M.D. (Ext. from Chicago Med. Jour. and Examiner.) 8vo, pp. 585–587. From the author.

Report on the Collection of Fishes made by Dr. Elliott Coues, U.S.A., in Dakota and Montana, during the season of 1873 and 1874. By David S. Jordan, M.D. (Ext. from the Bulletin of the U. S. Geol. and Geog. Surveys, F. V. Hayden, in charge. Vol. IV, No. 4.) 8vo, pp. 777–799. Washington, 1878. From the author.

Description of a New Species of Smynthurus. By John A. Ryder. (Ext. from Proc. Phila. Acad. Nat. Sciences, 1878.) From the author.

A Contribution to the Palæontology of the vicinity of Poughkeepsie. By T. N. Dale, Jr. (Ext. from Proc. Poughkeepsie Soc. Nat. Sciences, Dec. 4, 1878.)

Memoirs of the Geological Survey of the United Kingdom. Monograph IV—The Chimæroid Fishes of the British Cretaceous Rocks. By E. T. Newton, F.G.S., Assistant Naturalist. 4to, pp. 50, pls. XII. From the author.

Guide du Naturaliste, Revue Bibliographique des Sciences Naturelles. Bulletin Mensuel. Par A. Bouvier. (Zoologie, Géologie, Botanique.) Large 8vo, pp. 14. 1re Année, No. 1. Paris, Janv., 1879. From the editor.

Report on the Methods of Surveying the Public Domain to the Secretary of the Interior, at the request of the National Academy of Sciences. By J. W. Powell. 8vo, pp. 16. Washington, 1878. From the author.

Letter from the Secretary of the Interior, relating to the cost of geographical surveys. 8vo, pp. 6. (Washington, Feb. 7, 1879.) From the Secretary.

Letter from the Secretary of War, communicating further information in relation to a survey of the territory west of the Mississippi river, as proposed by the National Academy of Sciences. (Washington, Jan. 30, 1879.) From the Secretary.

Kæmpedovendyr–Slægten Cœlodon. Af. J. Reinhardt. 4to, pp. 257–349, Tab. 2. (Ext. from Vidensk. Selsk. Skr. 5 Række, naturvid. og mathem. Afd. XII, 3.) Copenhagen. 1878. From the author.

Catalogue of the Birds of Granada, from a collection made by Mr. Fred A. Ober for the Smithsonian Institution, including others seen by him but not obtained. By Geo. N. Lawrence. 8vo, pp. 265–278. (Ext. from Proc. Nat. Museum.) From the author.

1er Compte-Rendu de la Commission Géologique Internationale pour l'unification des procédés graphiques. By E. Renevier. 8vo, pp. 11. Lausanne, 1879. From the author.

Notice sur L'Ouvrage de M. le Professeur Heim intitulé: Mechanismus der Gebirgsbildung im Anschluss an die Geologische Monographie der Tœdi–Uindgællen–Cruppe. By E. Renevier. 8vo, pp. 9. (Ext. from Archives des Sci. Phys. et Natur. Nouvelle période, tome soixante-quatriéme No. 251. 15 Novembre, 1878.) Geneve. From the author.

Un Mot sur la Pêche de la Baleine et les Premiéres Expéditions Arctiques. Notice lue a Séance Publique de la Classe des Sciences le 12 Decembre, 1878. Par M. P. J. van Beneden. 8vo, pp. 22. Bruxelles, 1878. From the author.

Annual Report of the Wisconsin Geological Survey for the year 1878. By T. C. Chamberlain, chief geologist. 8vo, pp. 51. Madison, 1879.

Bulletin of the United States Geological and Geographical Survey of the Territories. Vol. 5. No. 1. 8vo, pp. 152. From the survey.

The Devonian Brachiopoda of the Province of Pará, Brazil. By Richard Rathbun. 8vo, pp. 14–39. (Ext. from Proc. Boston Soc. Nat. Hist., Vol. XX, May 15, 1878.)

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GENERAL NOTES.

BOTANY.

THE NUMBER OF STAMENS IN BRASENIA PELTATA.—There is quite a discrepancy among botanical writers regarding the number of stamens of *Brasenia peltata* Pursh, the common water-shield. A citation of a few of these, and some observations with a view to remove the differences, may not be out of place. My

attention was first called to this in 1872, when critically examining some specimens of the plant gathered at Bear lake, Van Buren county, Mich. The stamens were generally 24 or 25 in number. In 1875, specimens were collected at La Porte, Ind. My notes read, "Stamens indefinite, sometimes 27." They were usually not far from 24.

The past season it was found at Pine Lake county, Ind. The highest number of stamens noticed was 37, nearly always above 30, and commonly about 36. I also gathered specimens last summer at Old Mission, on Grand Traverse bay, Mich. The plants were advanced in flower and the stamens somewhat decayed, but were apparently 18 or less. In all these cases the stamens were picked out one by one, laid on a sheet of paper and counted, several flowers being taken in each locality. The conclusion from these facts is, that the stamens vary from about 18 to 37. It would be safe to say of the plant: stamens varying from 12 to some indefinite number.

Taking the most accessible authorities, especially in American botany, I find as follows: Gray's Manual, and Chapman's Flora of the Southern States, "Sta. 12–18." Gray's Structure and Systematic Botany, "Stamens definite, or nearly so." They may therefore slightly exceed 20. In Torrey and Gray's Flora of North America, Nuttall's Genera, Wood's Class Book (earlier edition), "Sta. 18–36. In Pursh's Plants of North America, Eaton and Wright's Botany (1840, genus Hydropeltis), Linnæus' Systema Vegetabilium (Sprengel's edition), "Class Polyandria," stamens 20 or more. In Rafinesque's Medical Botany of the United States (1828), "Sta. 20–30." In Michaux's Flora, under *Hydropeltis purpurea*, "Stamens numerous (about 36)." In Wood's Class Book, last edition, "Sta. 18–24." In Baillou's Dictionnaire de Botanique, Art. Brasenia, "Its stamens and carpels are indefinite." In Le Maout et Decaisne (Traité de Botanique) under Cabombeæ, including Brasenia, "Stamens 6, 12 or 18"—doubtless 12 or 18 for Brasenia, those of Cabomba being 3 or 6. In Eichler's Blüthen diagramme (1878), "Sta. 12–8."

From these references it is evident that there has been but little agreement as regards the number of stamens. While the older writers in general gave higher numbers, and in this more nearly accord with what I have found in the vicinity of Lake Michigan, yet it is probable that they are in error by not going below eighteen. Most of them also assigned the plant a southern or southerly habitat, on the Atlantic coast from New Jersey southward, west of the Alleghenies from Kentucky south. It may be that in these localities as in the north-west the number had a higher range. But the plants found in Northern Michigan would seem to indicate the lower number, and hence the entire range be covered by plants in this vicinity. This variation in number of stamens may be due to locality, or the season, or to

some inherent tendency in the plant itself. Consecutive observations in the same locality can best determine this. But this is immaterial to a correct statement in our text-books and works of reference. Assuming that all the authorities cited above are right, which may be shown to be true for some localities, as my experience in four localities proves, still there is need of a correction that shall include the experience of all. Eichler states the fact correctly, a conclusion I had already reached both from observation and a consultation of authorities, before receiving his book.

While collecting the facts for this paper I had noticed a tendency in the stamens to be multiples of six. Those found at Old Mission were apparently about 18 in number, those at Bear lake and La Porte about 24 (24–27), those at Pine about 36. This goes to confirm an observation of Nuttall (Genera, Vol. II, p. 24), which I had not read till arranging these facts for publication. Having stated that the stem is furnished with two sets of confluent central vessels, which, arriving in the leaf, resolve into twelve nerves, he continues: "As the elliptic form of the leaf originates from the eccentricity and duplicature of the central vessels, expanding in an ellipse or two intersecting circles, so we may justly consider it as a species of double leaf, hence also the stamina and the fruit is in the same manner augmented. In its coördinate *Cabomba*, which produces orbicular peltate leaves, we find only 6 stamina instead of 18, two or three styles and capsules instead of six or more, but containing the same number of seeds and of nearly the same form; hence we perceive the same type in its simple form. A proof of the small importance of mere number in the character of classes or of natural groups."

From this the inference is obvious that the doubling of the stamens would be in multiples of six. A plant with a tendency to double stamens that ranged between 12 and 18, would have from 24 to 36; those approximating the simple type *Cabomba* would be intermediate from 12–18, 18–24, 24–30, 30–36, &c.

Doubtless it is better to go back of this and say that the stamens are multiples of the three or four parts of which the calyx and corolla consist. The perianth of *Cabomba* is on the whole trimerous, the parts alternating. Eichler states: "Brasenia does not essentially differ from Cabomba except in its 12–∞ stamens, and 6–18 pistils." (Blüthten diagramme, Part II, p. 177.)

Though the stamens are not exact multiples of three and four in all cases, they vary but a little from it.—*E. J. Hill, Englewood, Ill.*

A Fairy Ring.—Last July my attention was called to a "Fairy Ring" on the lawn in front of a gentleman's residence in this city. It was a more perfect circle than could have been made by man unaided by instruments. The rim of the circle was about twelve inches in width, and the diameter from the inner edge about fifteen

feet. The lawn was covered with grass some three or four inches in height, and every blade forming the circle, was found on close inspection to be covered with minute globular bodies of a grayish color which, contrasting with the green of the lawn, made the circle perceptible at a considerable distance.

On the morning of its discovery the ring was not completed by six or seven feet. The next morning it was finished. Two smaller circles were also seen on the same lawn; one however was incomplete where it encroached on a gravel walk. When the circle was struck a small smoke like cloud arose. On examining with a microscope the blades of grass which formed the ring, they were found to be covered with clusters of globular, sessile bodies from one-fortieth to one-sixtieth of an inch in diameter, which externally resembled minute puff balls. Specimens sent to Prof. W. G. Farlow of Harvard University, were pronounced by him to to be a fungus of the order Myxomycetes (*Physarum cinereum*).—*B. C. Jillson, Pittsburgh, Pa.*

Insects as Unconscious Selectors of Flowers.[1]—Natural selection, the origin of new forms in the animal and vegetable kingdoms by the survival of the fittest, and artificial selection by man, agree in many points, though differing in others. In general they harmonize in the following respects. From generation to generation the number of individuals of every species in process of selection is increased, while the individuals of a given generation differ among themselves. Of these individuals, only such as surpass their fellows in certain directions are allowed to produce offspring; and these offspring inherit the peculiarities to which the prolonged existence of their parents is due. Hence we find that both modes of selection result in the accumulation of individual variations, all tending in a particular direction, so long as the conditions presiding over the survival of this or that individual remain constant. On the other hand, we find that these last conditions differ greatly in the two kinds of selection. Man arbitrarily destroys at once, or neglects all individuals which are neither pleasing nor profitable to him; while those which he spares become through successive generations more and more indicative of his wishes or needs. But natural selection preserves only such individuals as are best adapted to nourish and protect themselves and to produce offspring which may be widely disseminated, the offspring becoming from generation to generation better adapted to the performance of these duties. With flowers in a state of nature we find that the causes presiding over even the survival of individual forms are quite similar to those pertaining to human selection; for the insects which visit these flowers are guided like man by pleasure or profit; and, though they cannot weed out plants which do not satisfy them in either of these re-

[1] An abstract of a series of very interesting articles, entitled Die Insekten als unbewusste Blumenzüchter, by Dr. Hermann Müller, Kosmos, Band III, Heft 4–6.

spects, they can cease to visit them, and by this means cause their deterioration and final destruction through self-fertilization, while such as meet their wants are strengthened by repeated crossing. Here, then, we have to deal with something more than natural selection proper, namely, a methodical though unconscious selection by the insects. A most interesting question, and one well treated by Dr. Müller in his papers, is the following: "What peculiarities of flowers are to be attributed to insect-selection, and what to natural selection?"

When an anemophilous flower begins to become entomophilous, the first step is one tending to cause insects to come in contact with its stamens and pistil; and this is either the secretion of nectar in both forms of the unisexual flowers, or the union of the sexes to form a perfect flower. Adhesiveness of the pollen must also be developed in order to insure its transfer by insects from one flower to another. Nectar, being of great value to insects, and not directly useful to the plant, should be considered the result of insect-selection; but the adhesiveness of the pollen, being of immediate value to the plant, and only utilized in comparatively recent times by insects, should be considered as a result of natural selection. We must suppose that at first all flowers were equally accessible to all insects which chose to visit them. Through successive generations, however, the selective action of insects joined to natural selection wrought great changes, whereby the flowers were so modified as to adapt them to the visits of special groups of insects, which themselves experienced, by natural selection, changes fitting them to profitably visit the modified flowers.

Dr. Müller sums up the entire matter as follows: 1. All wild flowers are the result of the combined action of two different sorts of selection. Those peculiarities (such as attractive colors, odor, sheltered retreats, food, and the means of protecting this latter product against unbidden guests) which are immediately useful only to the insects which visit the flowers, are usually the result of the selection exercised by these insects themselves; but such peculiarities as are immediately useful only to the plant (the securing of crossing when insects visit the flowers, and of self-fertilization when they do not, and the protection of the reproductive organs against inclement weather and enemies) have been developed by natural selection, acting quite independently of the insects; finally those which are equally useful to both flowers and insects are the result of the combined action of both sorts of selection.

2. The first flowers were, for the most part, simple, regular and open, and were subjected to a mixed company of insect visitors, which succeeded in rendering permanent only conspicuous colors, odor, and nectar.

3. From this original mixed group, the carrion-loving Diptera,

with their tastes so different from those of other flower-frequenting insects, have become separated as independent selectors of flowers; and, through structural peculiarities enabling them to utilize certain modifications of the flowers, the butterflies, ichneumon flies, mining-wasps, wasps, bees, and syrphus-flies have likewise become separated.

4. The carrion-loving Diptera have bred flowers distasteful to other insects (Ekelblumen). Natural selection, coming to their aid, has produced various contrivances for securing cross-fertilization, such as kettle-traps (Kesselfallen) (*Aristolochia clematidis, &c.*), pinching-traps (Klemmenfallen) (*Asclepias, Pinguicula alpina, &c.*) and deceptive-flowers (Täuschblumen) (*Ophrys muscifera.*)

5. Longer tongued, more intelligent, and more dexterous insects have gradually been developed from those remaining, which differed from the Diptera, but agreed among themselves in their tastes. These insects have selected nectar, which less intelligent or shorter tongued insects could not find or reach, and also receptacles and shelter for the nectar, and marks guiding to it.

6. From this circle the butterflies were adapted by their slender tongues, and certain moths by their long tongues, to appear as independent selectors of flowers. The former have selected to their present perfection those flowers which are characterized by the narrowness of the passage leading to their nectar; the latter, such as possess greatly elongated nectaries. These flowers may be divided according to their time of blooming and their color, into diurnal and nocturnal butterfly-flowers, and diurnal and nocturnal moth-flowers, while we may distinguish many transitional forms. The well-developed sense of smell of the moths is indicated by the spicy fragrance of the flowers selected by them; the well-developed color sense of the butterflies, by the beautiful colors of the products of their selection.

7. Ichneumon flies surpassed all other flower-visiting insects of their time in their acute powers of perception, and thus they were able to select for themselves inconspicuous flowers which had escaped the notice of other insects. But after the appearance of the mining-wasps and bees, the ichneumon flies could retain their flowers only in places little frequented by these insects.

8. The mining-wasps probably superseded the ichneumon-flies as flower selectors, and selected those whose nectar was accessible only by forcing open closely appressed parts, creeping bodily into a cavity, or some similar action, easy only to insects accustomed to burrowing, or creeping into crevices. Later, however, bees came into partial possession of these flowers, and they further modified many of them.

9. Wasps were able by the power of their sting to secure sole possession of certain flowers which contained nectar and still remained open. These they selected in conformity with their

wants and tastes; but in places where wasps are not very abundant the products of their selection are shared by other insects.

10. As the most industrious and most skillful insects, and withal those most dependent upon flowers for food, bees have played the most prominent part in selecting flowers—at least in Germany. They have given us the most numerous, most diversified and most specially elaborated flowers, the visiting of which calls into play those faculties which the bees have acquired and inherited through their labors in caring for their young.

11. Finally, certain syrphus-flies, passionately fond of color, and themselves brightly colored, but not especially dependent upon flowers for food, have succeeded in producing certain flowers corresponding to their tastes; meantime natural selection has given rise to contrivances in these flowers which secure cross-fertilization through the instrumentality of these insects.—*Wm. Trelease.*

Botanical News.—In the February and March numbers of the *Botanical Gazette*, Mr. A. H. Curtiss begins a series of papers on the Botany of the Shell Islands of Florida. Mr. A. P. Morgan writes in the February number on the the phyllotaxis of leaves. Mr. C. R. Barns indicates the differences between *Heliopsis* and *Helianthus*, and Mr. C. H. Peck describes eight new species of fungi. In the March number Mr. A. M. Canby contributes some interesting notes on *Baptisia*, with a synopsis of American species.

Trimen's *Journal of Botany* for February contains an interesting biographical notice of Elias Fries, by A. N. Lundström, accompanied by a portrait. The ferns of Borneo are enumerated and a number of new species described by J. G. Baker. Jacob Bigelow, the author of the "Plants of the Vicinity of Boston," a book thumbed so much by botanical students twenty years ago, and which gave such a gentle and healthful stimulus to the walks of local botanists, died recently in Boston at an advanced age. Bigelow and other botanists owed much to the zeal and activity of Dr. J. W. Robbins, of Uxbridge, Mass., who died at about the same time.

ZOÖLOGY.[1]

The Oviposition of the Queen Bee and Dzierzon's Theory.—According to a classical theory which had its birth in Germany, and which no one now-a-days disputes, a fecundated egg of the queen bee is a female egg, and all unfecundated eggs are male. The mother bee, it is said, can even lay at will an egg of one or the other sex. This faculty, which is exceptional in the animal kingdom, is explained by assuming that the bee, at the moment of the passage of the egg into the oviduct, can apply to it or not

[1]The departments of Ornithology and Mammalogy are conducted by Dr. Elliott Coues, U. S. A.

a certain quantity of the seminal fluid contained in the seminal receptacle. Nevertheless the organization of the generative apparatus of the bee does not differ essentially from that of the majority of female insects, to which no one has ever thought of ascribing the power of acting at pleasure upon phenomena which seem to be absolutely removed from the influence of the will.

The hypothesis was set up mainly to explain the fact, which has hitherto not been disputed, that an Italian female fecundated by a German male furnishes hybrid females (workers and queens) and pure Italian males. The opposite would be the case if a German queen were fecundated by an Italian male; so that a male egg would never receive the seminal baptism, a drone would never have a father.

Now I possess at this moment a hive, the queen of which, the daughter of an Italian of pure race, has been fecundated by a French male. The workers in fact, are partly true Italians, others French, whilst others present a mixture in various proportions of the characters of the two races.

Being surprised to see in this hive certain drones amongst others as dark as French males, when according to the theory all ought to have been Italians, like their mother, I thought it necessary to examine these males more closely. I therefore collected three hundred of them and examined them most carefully, obtaining the following statistics: 151 were pure Italians, 66 were hybrids in different degrees, and 83 were French. From this it is evident that the drone eggs, like those of the females, receive the contact of the semen deposited by the male in the female organs; and the theory of Dzierzon, proposed to explain an insufficiently-ascertained fact, becomes useless if this fact is disproved.

It is easy to understand how an insufficient observation may have led to the belief that the drones, the sons of an Italian mother fecundated by a male of a different race, were all Italians. Of 300 males only 83 appeared to me to be strictly French, while 151 + 66 or 217, *i. e.*, the great majority, being yellower than the French drones, might easily pass for pure Italians. Thus, in such cases, if a great number of males in a hybrid hive have not been carefully examined one by one, it is easy to understand how it might be believed that they all belonged to the same race as their mother, especially when the latter belongs to the handsomer and yellower race.—*Comptes Rendus, Sept.* 9, 1878, *p.* 408.

Merrill's Ornithology of Southern Texas.—These notes comprise a list of birds observed in the vicinity of Fort Brown, Texas, from Feb., 1876, to June, 1878. The brochure is extracted from the Proceedings of the United States National Museum, and is valuable for the many field notes regarding the breeding habits of a number of the birds mentioned, with annotations by Dr. Brewer and Mr. Ridgway. Three plates of outlines add to the

value of the article. Twelve species of birds are enumerated which cross the Mexican border, and are thus new to our avifauna.

An Insect Borer in Powder Barrels.— We have received specimens of a Callidium (probably *C. variabile*), the larva of which have been found by Capt. McGinnis, U.S.A., to injure the hickory hoops of the powder barrels of the St. Louis Powder Depot. So injurious has this gnat proved that no inconsiderable sum is now annually spent in re-coopering barrels in order to make good the injury thus done. Means have been taken to prevent the ravages of the insects.

A Large Saw-fish.—In a communication from Samuel A. Shields, Jr., we are informed that the saw-fish (*Pristis*) which was caught in Grassy sound, opposite Five-mile beach, and about seven miles from Cape May city, measured sixteen feet in length, and six feet from tip to tip of the pectorals fins; its weight when caught was seven hundred pounds. The "saw" was four feet in length with twenty-four teeth on one side and twenty-five on the other.

Wrens and the Bee Moth. — My bees have at times suffered a little from the ravages of the moth. But in some seasons I have had several pairs of wrens nesting in boxes suspended from trees near my apiary, and I have noticed that during these years the moths are always scarce and but seldom seen. While my observation has not been accurate and systematic enough to enable me to say positively that the little birds, by catching the winged insects, prevented them from depositing their eggs in the hives, and thus saved the bees from the destructive ravages of the worms, I have always belived they were entitled to the fullest credit in that direction. I am so confident of their good offices, that I shall try and provide all that come to my premises with nesting-boxes, though I am well aware that the best possible protection is to keep the colonies of bees in the strongest possible condition. But I wish to give my feathered friends the amplest credit for all the good they do, and render all of the social kinds every assistance in my power.—*Chas. Aldrich, Webster city, Iowa*, 1878.

An Owl's Revenge.—In a village of the canton of Vaud, the inhabitants of a comfortable dwelling house discovered, last April, that a family of owls had taken up their abode under the same roof with them. There was a hole in the wall of the gable end about twenty feet from the ground, and in it these birds had made their nest. It was the first year that they had built in that place.

A young farmer and three or four of his friends who had frequently observed the owls entering and flying out of the cavity,

resolved to examine the nest. One Sunday in May, toward the close of the afternoon, they placed a ladder against the wall, whereupon the old birds flew out, and our young observers, going in turn to the summit, were able to gratify their curiosity by inspecting the family of owls. They found several young ones of extraordinary ugliness, and, according to their own account, after examining them they carefully replaced them in the nest. The parent birds did not that evening appear to be angered at the proceeding.

The next night, however, between 9 and 10 o'clock, as the young farmer was returning home followed by his servant-man some six or seven paces in the rear, on passing by the wall in question he heard a sound of wings and a violent exclamation at the same time from the servant. The latter, in evident pain and alarm, held his hands clasped over his right eye. He stated that the owl had flown suddenly down upon him, had driven her talons into his chin and then struck him upon the right eye with her beak. The blow, fortunately, did not fall on the eye-ball, and was not followed by any mutilation. Upon examination there were to be seen, besides a violent bruise below the eye, two bleeding wounds on the chin, the unmistakable imprint of the talons of the bird of night.

The man could not sleep during the night, partly from pain, partly from the necessity of applying cooling lotions to the injured part; he had plenty of time, therefore, to meditate upon vengeance, and the destruction of the nest was determined upon. But the next morning, about 5 o'clock, a cousin of the farmer passing by found the young owls on the ground at the foot of the wall. Unaware of the attack of the evening before, he gathered them up and with the aid of the ladder replaced them in their nest. Had some one taken these little creatures out? Had they fallen down? or, had the parents ruthlessly expelled them from the nest, no longer enduring them since human eyes had seen them in all their repulsiveness? To this no one can reply. It sometimes happens that a man fired with revenge, steals, knife in hand, behind his victim, strikes the fatal blow, and then discovers that he has mistaken the person. Such an incident occurred in Morges not long since. Was this the case with the owl? Were the young ones in fact taken from the nest the succeeding evening, and did the mother's vengeful beak merely strike the wrong person? It is impossible to decide this. The servant swore by all his Saints that he had not meddled with the nest, and that at the moment when he was attacked he was as innocent as a new-born child.

The next day witnessed a new act in the little drama. The owl, guilty both of malice and of a blunder, was speedily tried, condemned, and the suppression of the entire brood included in the sentence. Execution followed in the afternoon. The owls

were absent or had fled at the raising of the ladder, but the nest was destroyed and the young ones killed. Immediately afterward the parent-birds returned, exhibited the liveliest agitation, and flew backward and forward between the roof and a neighboring tree, snapping their beaks and uttering continual cries. The death of the old birds was also decreed, and for an hour or more the young man and his friends made vain attempts to shoot them. They were provided with an excellent gun, but the movement of the birds was so rapid that all their efforts were unavailing. Twilight came on, and still the owls pertinaciously hovered in the neighborhood of their ruined home. The friends becoming impatient went away, and the increasing darkness at length compelled the young man to give up his purpose. Just then the female owl flew into the dense foliage of a tree; into this the sportsman was about to fire at hazard when he suddenly heard a violent rustling of wings and leaves; the bird shot like an arrow across the thirty or forty feet of interval, M. F. received a fierce blow full on the left eye, and at the same time was conscious of the rapid apparition of two round flaming eyes close to his face. The shock and the pain were so violent that M. F. fell backward on the ground. The owls flew away, and only reappeared at long intervals during the ensuing days. The next morning after a night of suffering, the two wounded men arrived at Lausanne, the master in a car, with a bandage over his left eye, and the servant driving, with a bandage over his right. The injuries were as follows: the man presented a severe contusion of the tissues around the lower border of the eye, extensive swelling and infiltration of blood in the eyelids and under the conjunctiva. Ten or twelve days of cold applications removed all traces of the attack.

M. F., on the other hand, was seriously injured. An L-shaped wound had laid open the cornea, through the edges of which projected two fragments of the iris. The anterior chamber was obliterated, the crystalline lens crushed, and the tissues generally infiltrated from the hemorrhage. The patient could scarcely perceive the strongest light, and his sufferings were so acute that for some days injections of morphia were continually required.

(The details of the treatment of the case will not interest the readers of the NATURALIST, suffice it to say that after four weeks of suffering, during which iridectomy was performed, M. F. recovered a partial degree of sight in the injured organ, though Dr. Dufour is of the opinion that the eyeball will ultimately become atrophied.)

From this recital two conclusions may be fairly drawn:

1. That the owl is courageous enough not to fear attacking a man.

2. That when thus attacking, its blows are directed only at the eye. This intention, or these tactics, as it may be termed, was clearly shown in the two occurrences related.

It was not possible to ascertain exactly to what species these owls belonged. The adult birds could be neither captured nor killed, although, as may be supposed, after the second attack a price was set on their heads. All was without avail, they withdrew from the neighborhood, and were only seen again at long intervals.—*Translated by Dr. R. Fletcher from the Bulletin de la Société Medicale de la Suisse Romande.*

ANTHROPOLOGY.[1]

THE INTERNATIONAL CONGRESS OF ANTHROPOLOGICAL SCIENCES HELD IN CONNECTION WITH THE UNIVERSAL EXPOSITION AT PARIS, AUGUST 16–21, 1878.—*First Day.*—Opening address of the President, Dr. Paul Brocâ. Report upon anthropological societies and instructions in anthropology, by Dr. Thulie. Report upon anatomical, biological, and pathological anthropology, by Dr. Paul Topinard. Report upon ethnology of Europe, of Western Asia, and America, by M. Girard de Rialle. Report upon the ethnology of Eastern Asia, Africa, and Oceanica, by Dr. Bordier. First report palæoethnology—geological times, by M. Gabriel de Mortellett. Second report upon palæoethnology—neolithic period, or that of polished stone, by M. Emile Cartailhac Report upon Demography in relation to Anthropology, by Dr. Chervin.

Second Session.—Physical development of the two sexes in Italy, by M. Paghani. Relations of the conformation of the skull with intelligence, by M. Le Bon. Notes upon the East Indians transported into Guiana, by Dr. Maurel. Notes on the hair, by Dr. Latteux. Relations of the proportions of the skull with those of the body, by Madame Clemence Royer. New dolmens in Portugal, by M. Da Silva.

Third Session.—Anthropological mensurations, by Professor Stieda. The legend of the *Nuttons*, and the origin or cause of its expansion, by M. Edossard Dupont. Anthropological and ethnographical notes on Central Asia, by M. de Ujfaloy. Anthropometry, by Dr. Paul Topinard. Nineteen brains of criminals, by M. Benedict. A Tumulus on the banks of the Parana, Buenos Ayres, by M. Estasnilas Ceballo. Upon the arrival of the Bohemians in Europe, by M. Bataillard.

Fourth Session.—The ancient Guanches, by Dr. Chil y Naranjo. Creation of laboratories in the colonies of different States, by Prof. Virchow. Incised bones of cetaceans of the tertiary epoch, by Professor Capellini. The flaked flints of St. Acheul, by M. d'Acy. A cemetery of the epoch of bronze at Pogues (Niévre), by M. Jacquinot. Digging in the grotto of the Mammoth, Poland, Count Zawisha.

Fifth Session.—The ancient monuments on the banks of the Vistula, by M. Zaborrowski. Homotypical characteristics of the thoracic and abdominal members, by M. Alexis Julien. Differen-

[1] Edited by Prof. OTIS T. MASON, Columbian College, Washington, D. C.

tial characters of the inferior and superior races of men, by M. Abel Hovelacque. An indication of ante-Columbian relations between America and Europe, by M. G. de Mortillet. Monograph upon the grottoes of human origin in the neighborhood of Brives, Correze, by E. Rupin and Ph. Lalande. The chipped flints from the north of Africa, and from the Orient, by Abbe Richard. Presentation of the album of the first age of iron. and of a palæoethnological atlas of the Departments of France, by M. E. Chantre. Pre-historic man in the basin of La Plata river, by Fl. Ameghino.

The communication of M. de Mortillet, whom we have learned to regard with especial reverence, is certainly premature, to say the least. The St. Acheul axes, alleged to be pre-glacial and intra-glacial, are found by the hundreds on the surface all along our eastern rivers. It is to be hoped that the patriarch of archæology will suspend his judgment until the facts are more fully in hand.

The paper of M. Ameghino is very interesting and is well reported in the seventh and eighth numbers of Materiaux, from which magnificent journal this account is taken.

THE FOLLOWING IS A LIST OF SOME ANTHROPOLOGICAL CATALOGUES OF THE PARIS EXPOSITION, 1878.—Catalogue de l'Exposition des sciences Anthropologiques. Supplement au Catalogue des produits de l'Autriche. Vienne, Juin, 1878. 40 pp., 8vo.

Dr. G. C. M. Birdwood, Exposition Universelle. Manuel de la section des Indes Britanniques. Londres et Paris. 144 pp., 8vo., 5 pl. 1 ft. 25.

Catalogue raisonné des Antiquités du nord firmo-ougrien exposeés par l'Université Alexandrine d'Helsingfors a l'Exposition Universelle de 1878. 36 pp., 8vo., avec gravures.

Catalogue des crânes d'origine finnoise exposés par le musee d'anatomie de l'Université Imperiale d'Alexandre, en Finlande, a l'exposition des sciences anthropologiques. 20 pp., 8vo., une carte.

España: Catalogos de las secciones de ciencias anthropologicas y de arte retrospectivo. Madrid, 1878. 56 pp., 8vo.

Catalogue special de la section anthropologique et paleontologique de la République Argentine. 80 pp., lithog, Paris.

Exposition Universelle de Paris. Exposition ethnographique du musée d' ethnographie Scandinave à Stockholm, représenté par le Dr. Arthur Hazelius, fondateur et directeur du musée. 8 pp., 8vo.

Catalogue des objets envoyés à l'Exposition Universelle de Paris, en 1878, par les exposants du departement de la Savoie. Chamberry, 1878; p. 302–355 consacrées a l'exposition anthropologique.

Philbert Breban: Livret-guide du visiteur à l'exposition historique du Trocadero, Paris, Dentu. 1 fr.

Tarameli Torquato: Note succincte sur l'Atlas de l'Orographie

des Alpes orientalis dans les periods tertiaire et postertiaire, essai de géologie continentale exposé aux sciences anthropologiques; Trocadero, Pavie, 1878. 12 pp., 8vo.

A. Mariette Bey: La galerie de l'Egypte ancienne a l'exposition retrospective du Trocadero. Description sommaire, Paris, 1878. 126 pp., 8vo.

Chauvet et Liévre: Les tumulus de la Boixe. Angoulême, 1878. 44 pp., 6 pl.

G. Chauvet: Notes sur la période neolithique dans la Charente. Angoulême, 1878, 25 pp., 3 pl.

Rules for the organization, in 1879, of an Anthropological Exposition of the Imperial Society of the Friends of the Natural Sciences, of Anthropology and Ethnology attached to the University of Moscow (confirmed by order of the government, May 20, 1878). We extract certain paragraphs of the circular, as being of general interest.

I. In order to familiarize the public with the questions of anthropology, principally respecting Russia, and to found at Moscow an anthropological museum as complete as possible, an anthropological exposition will be organized at Moscow during the summer of 1879.

II. The exposition shall be composed of objects having relation: 1. To the anthropological study of races which inhabit Russia. 2. To ante-historic races of that country (pre-historic archæology). 3. To general anthropology and to the systematic classification of races.

III. The objects admitted to the Exposition may be classed as follows:

1. Works concerning the anthropology and ethnology of Russia, and pre-historic archæology.
2. Charts of the distribution of races, and pre-historic monuments.
3. Photographs of types of different races, views of characteristic localities for the study of their customs, photographs and designs of costumes, utensils, habitations, and scenes displaying the manners of primitive peoples.
4. Busts and lay figures of different types.
5. Models of habitations and of costumes of primitive peoples.
6. Objects of domestic use, or having relation to the beliefs and the industry of the lower races.
7. Statistical tables of births, deaths, &c.
8. Models of tumuli (*Kourganes*) and of tombs.
9. Objects taken from ancient tombs, or pertaining to the pre-historic epoch.
10. Charts of geological sections and important localities for the study of ante-historic man; plans, models and designs of caverns.

11. Specimens of minerals which have served as material for ante-historic and primitive man for the fabrication of tools, and charts of their distribution.
12. Specimens of fossil and extant plants which are important in the study of the conditions of existence as affecting primitive races.
13. Remains of characteristic animals, or such as are related to the conditions of existence among the lower races. Skeletons and anatomical models of existing animals necessary to the comparative study of fossils.
14. Apparatus of anthropological research.
15. Anatomical models for the comparative study of races, necessary for instruction and the study of general anthropological questions.
16. Chemico-technical investigations upon objects of prehistoric archæology.
17. Elementary manuals designed to impart knowledge concerning the races of men, used in the courses of history and geography of the primary and secondary schools.

ANTHROPOLOGICAL NEWS.—Robert Clarke & Co., of Cincinnati, have issued a pamphlet of 75 pages, by Judge M. F. Force, containing two papers, the first of which is entitled, "Some Early Notices of the Indians of Ohio," the second, "To what Race did the Mound-builders belong." In the latter half of the seventeenth century, after the destruction of the Eries by the Five Nations, in 1656, what is now the State of Ohio was uninhabited. In the next half century, the first half of the eighteenth, various tribes pressed into Ohio. The Wyandots, or Hurons, extended their settlements into the North-western portion of Ohio and became permanently fixed there. Shawnees settled the Scioto Valley, Delawares moved to the valley of the Muskingum. Little detachments of the Five Nations, mostly Senecas, occupied part of the northern and eastern borders. The band of Senecas who settled between the Muskingum and the Pennsylvania border were called Mingoes. Parties of Cherokees often penetrated north of the Ohio, between 1700 and 1750, and later a party of them settled among the Wyandots, in the neighborhood of Sandusky. The history of the Eries and the Shawnees occupies the most of the first paper. and is well fortified by references to the original authorities from which the author has drawn. The paper upon the Mound-builders was read before the Congrès International des Americanistes, at Luxembourg, September, 1877. The conclusions to which the author arrives, are as follows: "The present state of information, therefore, leads to the conclusion that the Mound-builders were tribes of American Indians of the same race with the tribes now living; that they reached a stage of advancement about equal to that of the Pueblo Indians; that they were flourishing about a thousand years ago, and earlier and later; and

that at least in the tribes near the Gulf of Mexico were preserved some of their customs and some of their lineage, all after the discovery of America."

On page 56, mention is made of trees on the mounds, six hundred years old, and this remark follows: "Some of the works, therefore, must have been abandoned six or eight hundred years ago. It is quite possible that they were abandoned earlier, for these surviving trees may not have been the first to spring up on the abandonment of the work."

It is well to bear in mind the following facts before basing a chronological deduction upon trees: 1. The outer rings of a stump are very much narrower than the inner rings. If a section of the outer part of a stump decayed in the centre be counted, and the number of rings be multiplied by the ratio of the thickness of this section to the radius, it will give the age of the tree far greater than it really was. A ratio of increment could easily be obtained by examining a large number of stumps. Will not some one make the calculation for us? 2. Although the ground from which oak forests are cut, springs up thickly with pines, yet any one, by walking through these pines, will find here and there oaks which in the long struggle for existence will overtop the growth which now conceals them. 3. What evidence have we, that trees, especially nut-bearing trees, were not allowed to grow upon these works by the Mound-builders while they were still in possession of them? If this be true, all we can say is, that the mound or work was constructed (not abandoned) so many years ago.

These slight queries must not be allowed to detract from the value of Judge Force's highly meritorious work, especially with reference to the Eries and Shawnees, the latter of whom seems to have been the Gypsies of North America.

Mr. J. D. Putnam, Secretary of the Davenport Academy, sends us photographs of two mound pipes, one of them representing an animal like a bear, the other (mirabile dictu!) an elephant. The former creates no surprise; the latter is so like an elephant in body, limbs, head, trunk, all but tusks, that we have no hesitation in saying that the maker of it had seen an elephant, and tried to reproduce his likeness in this pipe. It was taken from a mound in Muscadine county, Iowa, and, so far as the integrity of the finder is concerned, is a genuine mound relic. It is impossible to state what the significance of this find may be; coupled with the discovery of an elephant mound in Grant county, in the adjoining State of Wisconsin, it seems to point to a former connection of the mammoth with man on our continent. By preserving the most scrupulous account of these ancient landmarks we may, in time, be able to explain their significance by further discoveries.

GEOLOGY AND PALÆONTOLOGY.

THE GENUS CŒLODON.—In the Vidensk. Selsk. Skr. v, 1887, Prof. J. G. Reinhardt gives the first full account of the genus *Cœlodon* of Lund, heretofore only described from a few fragments. The remains were all found by Lund in Brazil, and include, besides the fragments of the *C. maquinensis*, a skull and a good many bones of the skeleton of a second species which is described by Reinhardt as *C. escrivanensis*. The characters of the genus are very interesting, being near to *Megatherium*, although the species were not larger than the great ant-eater. The paper is well illustrated.

DAWSON ON EOZOÖN.—In the last number of the *Amer. Journ. of Science and Arts*, Prof. Dawson criticises the memoir of Möbius mentioned in the last number of the NATURALIST. He thinks that Dr. Möbius has misinterpreted the evidence derived from his specimens. Thus he has mistaken the veins of chrysotile, which traverse the serpentine and calcite, for the walls of the *Eozoön* chambers. His objections to the unsymmetrical and irregular forms of the large so-called tubules, are met by the statement that these irregularities are due to pressure, faulting and other incidents of fossilization. The regular round and branching tubules, regarded as accidental by Möbius, are stated to be the normal structure by Dawson.

A NEW GENUS OF PERISSODACTYLA.—In 1873 I described a species of ungulate, supposed to be related to the *Rhinocerida*, from the White river beds of Colorado, under the name of *Hyracodon quadriplicatus*. Further investigation shows that this animal represents a genus hitherto unknown, whose affinities are probably as much to the tapirs as to the rhinoceroses. The molars have the form and structure of those of *Lophiodon*, and the third and fourth premolars have the same characters as the true molars, which is not the case in that genus. The second premolar presents the elongate form characteristic of some species of *Anchitherium*. It has two cross-crests, and the external longitudinal crest presents three lobes besides the anterior and posterior prolongations, somewhat as in the corresponding deciduous tooth. I call this genus *Anchisodon:* the species *A. quadriplicatus* was as large as the *Accratherium occidentale*. A second species has been found in the John Day region of Oregon, in the White river formation. Its molar teeth differ in the presence of a fossa which is isolated by the contact of the edges of two processes, one from the external crest, the other from the posterior cross-crest. The anterior cross-crest has no processes; there is a compressed tubercle at the entrance of the transverse valley, but no cingulum on the posterior base of the crown as in *A. quadriplicatus*. The fore and aft diameter of a middle molar is .028 m., the transverse .028. The anterior crest is strongly recurved, and the posterior notch

is profound. Enamel smooth. The species may be called *Anchisodon tubifer*.—*E. D. Cope.*

A New Genus of Ichthyopterygia.—Prof. Marsh has recently described a genus which he does not distinguish from *Ichthyosaurus* excepting by the entire absence of teeth, and even of a dental groove. He names the genus *Sauranodon*. The only known species *S. natans* is from the marine Jurassic of the Rocky mountains, and is about nine feet in length. Prof. Marsh proposes to regard *Sauranodon* as the type of a new order, but the only reason he assigns for this course, the absence of teeth, is insufficient.

Muschelkalk Fossils in Idaho.—In the last number of the *Bulletin* of the Hayden Survey, Dr. A. C. Peale describes certain mesozoic strata of South-eastern Idaho, which contain both Jurassic and Triassic invertebrate fossils. The lowest of these contains Cephalopods described by Dr. White, which Mr. Hyatt regards as more nearly allied to the forms of the Muschelkalk, although they are associated with some Jurassic species, one of which is also doubtfully identified from the top of the section.

GEOGRAPHY AND TRAVELS.[1]

The Dutch Arctic Expedition. — In the Naturalist for August, 1878, mention was made of the sailing of the small schooner *Willem Barentz* from Ijmuiden, on the 5th of May, 1878, for the Arctic seas. This preliminary voyage was chiefly undertaken to give experience in ice navigation to officers and men, as well as to make scientific observations in the Barentz sea, between Spitzbergen and Novaya Zemlya, and is expected to be followed by a second and more important expedition. For an account of the experiences of this small company of fourteen souls, we are indebted chiefly to Mr. Clements R. Markham.[2]

After calling at the Norwegian port of Bergen, they set sail on the 18th of May for Jan Mayen, arriving in sight of this remote volcanic island on a fine day, June 9th. The view, so rarely enjoyed in this region of continual fog, was impressive. The island is thirty miles long and nine broad, and at the north end rises the remarkable volcanic peak, Beerenberg, 6300 feet in height, covered with snow almost to the water's edge, and presenting a most imposing appearance, the high jagged summits of the lower hills, from which smoke was slowly rising, appearing quite dwarfed in comparison.[3]

A storm arising prevented their landing, and on the 12th they

[1] Edited by Ellis H. Yarnall, Philadelphia.

[2] *Proceedings Royal Geographical Society*, January, 1879.

[3] See *Illustrated London News* for October 26, 1878, for view of Jan Mayen from photograph taken on board of the *Willem Barentz*. Also number for January 25, 1879.

reached the edge of the west ice, and keeping along the line of this ice they reached the north-western end of Spitzbergen on the 19th. "Spitzbergen has justly earned its name, for one sees nothing but sharp-pointed rocks showing amongst the colossal glaciers, while the sun, throwing a red glow, brings the whiteness of the snow into startling contrast with the deep shadows." On the 27th they reached their furthest northern point in 80° 18′ N., off Verlegen Hoek. After stopping at Amsterdam island to erect a memorial slab of granite in the midst of the graves of Dutch whalers who died there in 1633–5, and touching at Bear island they arrived at Vardö, in Norway, on the 22d of July, and then commenced the reconnaisance of the sea of Barentz, sailing north along the 45th meridian. Ice was again met on the 1st of August at 77° 10′ N., and after proceeding westward and attaining a point (lat. 77° 44′ N., long. 35° 30′ E.) eighty miles from Wyche island, they were driven to the south by heavy gales. To the eastward of longitude 38° the ice was found to be thin, level and rotten, while to the westward there were heavy floes of immense thickness with hummocks thirty feet high. In the beginning of August they appeared to be on the boundary line where the warm and cold currents meet. Up to that time they found that the temperature of the sea decreased with its depth; but here they met with cold and warm currents flowing one over the other. The explorers next proceeded to Novaya Zemlya, and proceeding northwards along the coast to Cape Nassau, steered to the north-west and found the ice-field on September 7th in 78° 17′ and 55° 14′ E. From here the *Willem Barentz* made her way to Hammerfest, and this successful trip was finally ended at Amsterdam on the 13th of October. Experience of the ice movements between Spitzbergen and Novaya Zemlya had been acquired, a full hourly series of meteorological observations had been taken as well as deep sea soundings and magnetic observations and very valuable collections in natural history made. Notwithstanding almost constant fogs an excellent series of photographs was completed.

The Norwegian North Atlantic Expedition.—During the past three summers a Norwegian expedition under the charge of Dr. Mohn, Dr. Sars and other scientific men has been exploring the sea between Norway, the Ferroe islands, Iceland and Spitzbergen. Being well supplied with the most recent inventions for dredging, sounding, obtaining sea temperatures, etc., the scientific results are stated to be very satisfactory. Their investigations have now been concluded. The three summers have yielded in all 375 sounding stations, 113 temperature series, 44 dredgings and 42 trawlings. It was ascertained that during June and July the minimum temperature of the water off the coast of Norway is neither at the bottom nor at the surface, but at some intermediate strata of considerable depth. The explanation offered is

that in winter the cold water of the surface descends on account of its increased weight, until it reaches a stratum where the superincumbent water causes by pressure an equal density. In the warm months the surface water becoming heated has no tendency to sink. The warm Atlantic current was traced to the north of the eightieth degree of latitude along the west coast of Spitzbergen.

GEOGRAPHICAL NEWS.—The parties under Lieut. G. M. Wheeler, Corps of Engineers, continued their work during the season of 1878, in California, Colorado, Nevada, Oregon, Texas, New Mexico, Utah and Washington Territory, and surveyed approximatively 35,000 square miles, commencing July 1st and ending December 25th. Lieut. Wheeler was with party No. 1, California section, in the region north of a line joining Fort Klamath, Oregon, and Camp Bidwell, California, northward to the Columbia river. Prof. Stevenson, geologist, and his assistant, Mr. Russell, investigated the coal fields of Colorado and eastern New Mexico, and Mr. Henshaw continued to increase his zoölogical collections in California and Oregon.

Recent geographical publications in Germany include: Aus Mexico, Reiseskizzen aus der Jahren 1874 und 1875, von Dr. Fr. Ratzel; Reise durch den Stillen Ocean, von Max Buchner; Die Sahara, oder von Oase zu Oase, Bilder aus den Natur und Volksleben in der grossen afrikanischen Wüste, von Dr. Josef Chavanne; Die Literatur über die Polar Regionen der Erde, von Dr. Josef Chavanne; Abriss der praktischen Astronomie, vorzüglich in ihrer Anwendung auf geographische Ortsbestimmung, von Dr. A. Sawitsch nach der zweiten russischen Original Ausgabe; Ethiopien-Studien über West-Afrika, von Dr. W. Hübbe-Schleiden, and Beiträge zur physischer Geographie der Mittelmeerländer besonders Siciliens, von Theobald Fischer.

Dr. Edwin R. Heath, of Wisconsin, sailed from New York November 18, 1878, for Para. He expects to explore the Beni and Madre di Dios rivers of Brazil. He has already spent some years in South America and is well prepared for the difficult work he has undertaken.

The newly colonized "northern territory" of South Australia is not the desert it was recently thought to be. The appearance of the natives is very gaunt and peculiar, their black faces being painted across with bands of white, so that they have a death's-head like appearance. It is stated that they cut off a joint from the finger of a mother for every child of hers that dies. As they also kill their weakly or delicate children, this practice is likely often to be of considerable inconvenience.—London *Times.*

The Russian government survey for a railway between Orenburg and Tashkend is finished and shows that it is quite possible to carry the line through the desert of Kara-Kum. An exploration will be made in 1879 towards Samarcand and in the direc-

tion of Cabul and Peshawur. Col. Prejevalsky will shortly set out on his new exploring expedition to Kuldja, Thibet and the Himalayas.

The last supplement to *Petermann's Mittheilungen* is devoted to an elaborate monograph by Dr. G. A. Credner, of Halle University, upon deltas. The paper is divided into two sections. In the first he treats of the limits of deltas, their character, and formation of their surface, their size, power, material, rate and results of growth, their age, number and geographical distribution and classification. In the second he treats of the origin and causes of the formation of deltas, and the geological problem thus presented. Maps showing the various deltas and illustrating the upheaval and subsidence of land are also given.

The British Arctic exploring ship *Alert* has again been put into commission under her old captain, Sir George Nares, for surveying service in Magellan's straits and the south Pacific. The work in Magellan's straits is expected to occupy from one to two years. The *Alert* will then proceed to make isolated but important surveys in the neighborhood of the Society, Friendly and Fiji islands and of shoals and reefs between the Fijis and New Zealand, and finally on the south-western and north-western coasts of Australia.

Major Herbert Wood and other writers have heretofore confidently asserted that the ancient river Oxus (now the Amu Darya) has within historic times emptied into the Caspian sea, and that its ancient channel can still be traced. The recent breaking down of a dam at Fort Bend on the Amu, which has caused a deviation of its waters in the direction of this old bed, has originated the report mentioned in the London *Times* that the river was about to resume its former course. Prof. Kiepert now writes to the Berlin *National Zeitung* to deny this report. He asserts that the old bed of the Oxus belongs to geology and not to history and that the project of completely restoring the ancient water-course and opening a new water way from Moscow to the heart of Asia is one which would overtask the resources of the richest state.

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SCIENTIFIC NEWS.

— In December, 1878, Dr. Gustav Leonhard, of Heidelberg, died, leaving the editorial management of the Jahrbuch für Mineralogie, so long and favorably know in America, in the hands of Dr. Hans Bruno Geinitz, of Dresden. Now, after sixteen years association with Dr. Leonhard, Dr. Geinitz retires from the editorship. The dissolution of this distinguished partnership will create a new feature in geological literature, and we can only wish Dr. Geinitz the same success in the cultivation of his favorite science in the future that he has had in the past.

— We regret to learn that in the great press of business which occupied the last hours of the late National Congress, the amendment to the Legislative, etc., Appropriation Bill, abolishing the existing Geological Surveys of the Territories, was passed. The fact that this measure had been defeated in the Committee on the Whole, and also in the House by votes of two to one, did not prevent its passage in consequence of a transfer at the last moment to the Sundry Civil Bill. A large number of scientific men will now have opportunity to repent at leisure their apathy in having allowed the substitution of one organization in place of three or four, which will, in all probability, not receive from Congress even the third of the aid which the surveys have been accustomed to obtain. The only remedy is to give the direction of the new Bureau to the man who has shown himself most influential in impressing Congress with the importance of making large appropriations for scientific work. The plausible plea that the geological surveys have been misused for the prosecution of zoölogical and other work, however it may affect the Executive, will not receive much sympathy from men of science. It is not true that a generous sympathy with all branches of science unfits a man for the directorship of a scientific survey.

— With much regret we have to announce the death of the distinguished palæontologist and comparative anatomist, Paul Gervais, which took place on February the 10th, in Paris. Prof. Gervais was born at Paris, on September 26, 1816. After taking the degree of doctor in science and medicine, he served as one of the aide-naturalistes of the Muséum d'Histoire Naturelle. In 1841 he became professor of zoölogy to the Faculté des Sciences of Montpellier; and on the death of Gratiolet, in 1865, he was appointed to the vacant professorial chair at the Muséum d'Histoire Naturelle, which he filled till his death. M. Gervais' powers and industry are attested by the value and number of his scientific papers, which in 1873 amounted to a hundred and sixty-four in number. In these he touched on almost every group of the animal kingdom; but his principal attention was directed to the higher classes, especially to the mammalia, recent and extinct. Of his separate works the most generally known are his Zoologie et Palèontologie Françaises, Zoologie et Paléontologie générales, Ostéographie des Monotrèmes, and (in collaboration with Prof. P. van Beneden) his Ostéographie des Cétacés; both of the last-named works are unfortunately left unfinished. He was principal editor of the Journal de Zoölogie.

In 1873 M. Gervais was elected a member of the Académie des Sciences, and he was a foreign member of the geological and zoölogical societies of London.

Prof. Gervais was one of the few living authorities on the palæontology of the Vertebrata, and was engaged at the time of

his death on a work on the minute structure of the bone of the various groups of Vertebrata. He leaves a son who is an able anatomist.

— The Geological Society of London has awarded to Prof. E. D. Cope the Bigsby Gold Medal in recognition of his services to palæontology.

— It appears that the Legislature of Pennsylvania is in some danger of failing to make appropriation for the continuation of the Geological Survey. We very much regret the existence of such a possibility, and hope that our legislators will carefully consider the interests of their constituents in this matter. Nothing is more valuable to a commonwealth than an inventory of its actual possessions, with a knowledge of their distribution and the methods of making them available. A knowledge of the physical constitution of a region is also an essential in the educational system of its inhabitants. Neither of these ends can be accomplished without the Geological Survey made by experts in the science, and no class of public servants produces more valuable work for less money than they. By all means continue the survey.

— We have received the first number of the Guide du Naturaliste. Revue bibliographique des Sciences Naturelles, Bulletin mensuel. Par A. Bouvier. Paris, 1879. (Un franc le numéro.) This is a valuable and newsy monthly, giving full details of contents of the journals and proceedings of the scientific societies of France, with courses of lectures in botany, zoölogy and geology.

— An elaborate and fully illustrated essay, by Dr. Hermann Müller, on the Cross-fertilization of plants, extracted from Schenk's Handbuch der Botanik, has been received too late for careful review.

— Early in January about five million young codfish were turned into the sea by the assistants of the United States Fish Commissions stationed at Gloucester, Mass.

— At the annual meeting of the California Academy of Sciences, held Monday, Jan. 6th, the following officers for 1879 were elected: President, George Davidson; corresponding secretary, S. B. Christy; director of museum, W. G. W. Harford.

— The Marquess of Tweedale, better known as Viscount Walden, President of the Zoölogical Society of London, died Dec. 29th, 1878. He was an active ornithologist, paying especial attention to the birds of the East Indies.

— Victor Ghiliani, one of the founders of the Italian Entomological Society, died in May last at Turin. Dr. Wilhelm Engelmann, the eminent German publisher of scientific books died at Leipzig, December 23.

— Congress has passed a bill appropriating $250,000 for a fire-proof National Museum, adjoining the Smithsonian Institution.

— According to *Nature*, the widow of the late Prof. Eichwald has presented the remarkable palæontological collections of her husband to the St. Petersburg University. The collection contains upwards of 30,000 specimens of fossils, from the various formations of Western Europe, from the Petchora Land, from the Aleutians islands, Siberia, Crimea, etc.

— Vögelbilder aus fernen Zonen, is the title of an atlas of foreign birds, just published by Fischer, of Cassel, under the care of Dr. Ant. Reichenow. It is noticed favorably by *Nature*.

— Fresh attention is drawn to the study of microscopic organisms by the appearance of part one, of the third volume of Stein's great work on Infusoria; as well as by a translation of Bütschli's essay on the Flagellate Infusoria (referring to H. James Clark's work done on American forms), and also by H. B. Brady's descriptions of deep sea Rhizopods in the *Quarterly Journal of Microscopical Science*.

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PROCEEDINGS OF SCIENTIFIC SOCIETIES.

New York Academy of Sciences, Dec. 9, 1878.—Prof. Henry Wurtz exhibited a large series of the minerals from the Silver Islet, Lake Superior, and described under the name of Huntilite (in honor of Prof. T. Sterry Hunt), a new species of silver ore from that locality. Huntilite occurs both massive and minutely crystallized, and is essentially an arsenide of silver, occupying the gap in mineralogy between dyscrasite and domeykite; dyad metals, especially nickel, appear to have replaced some part of the silver, and antimony a small part of the arsenic. Prof. Wurtz gave minute and laborious analyses and many interesting details.

Dec. 23d.—Mr. A. A. Julian made a communication on the glacial excavation of the Kaaterskill Clove. Mr. B. B. Chamberlin exhibited a series of minerals from the zinc and lead mines of Wisconsin.

Jan. 6, 1879.—Dr. Ephraim Cutter addressed the Academy on Tolles' one-seventy-fifth-inch objective—its history, construction and use (with sciopticon illustrations).

Jan. 13.—Prof. Henry Wurtz presented before the Chemical Section, further particulars of his new mineral, Huntilite, from the Silver Isles of Lake Superior.

Jan. 20th.—Mr. S. W. Ford read a paper on the structure and development of certain primordial trilobites. Mr. A. A. Julian remarked on the conglomerate from the sand-beds of Southeastern New Jersey. Dr. R. P. Stevens made a communication on the glacial moraine at Jamaica, Long Island.

Jan. 27th.—At a meeting of the section of Biology Dr. Charles

F. Taylor presented the results of some practical studies in Psycho-biology, with especial reference to the influence of mental states on disease.

March 3.—Mr. W. R. Gerard read a Note on the influence of sulphurous acid gas on coniferous trees.

American Geographical Society, Feb. 27.—Lieut. T. B. M. Mason, U.S.N., read a paper entitled the Preservation of life at sea.

March 11.—Gen. R. E. Colston lectured upon Life in the eastern and western deserts of Egypt and the Soudan, among the Bedouin tribes, with a description of their manners and customs, the waterless land, the mirage, the animals—especially the camel.

Boston Society of Natural History, Feb. 19.—Mr. H. G. Kittredge read a paper on the Natural history of Cotton. Mr. L. S. Burbank made a communication on the Clay beds of ancient estuaries.

March 5.—Prof. W. G. Farlow read a paper on North American Characeæ, and Mr. W. O. Crosby spoke concerning a possible origin of petrosilicious rocks.

Appalachian Mountain Club, March 12.—Mr. G. F. Hammett read a paper on the Practical application of mountain sketching, and Mr. W. O. Crosby spoke on the Pitch Lake of Trinidad.

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SELECTED ARTICLES IN SCIENTIFIC SERIALS.

Siebold and Kölliker's Zeitschrift für wissenschaftliche Zoologie.—December 19, 1878. The sexual organs of Cephalopoda, by J. Brock. Sixth paper on the structure and development of sponges, by F. E. Schulze. Studies on the anatomy of breathing organs—I. On the anatomy of the gills of Serpula, by L. Löwe.

Bulletin of the U. S. Geological and Geographical Survey of the Territories, Vol. v, No. 1.—Notes on the Aphididæ of the United States, with descriptions of species occurring west of the Mississippi, by C. V. Riley and J. Monell. The relations of the horizons of extinct vertebrata of Europe and North America, by E. D. Cope. Observations on the faunæ of the Miocene Tertiaries of Oregon, by E. D. Cope. Notes on the birds of Fort Sisseton, Dakota Territory, by C. E. McChesney. Palæontological papers—No. 9. Fossils of the Jura-Trias of Southeastern Idaho, by C. A. White. Jura-Trias section of Southeastern Idaho and Western Wyoming, by A. C. Peale. Fossil forests of the volcanic Tertiary formations of the Yellowstone National Park, by W. H. Holmes. Palæontological papers—No. 10. Conditions of preservation of invertebrate fossils, by C. A. White. Supplement to the bibliography of North American invertebrate palæontology, by C. A. White and H. A. Nicholson.